Control ENGINEERING

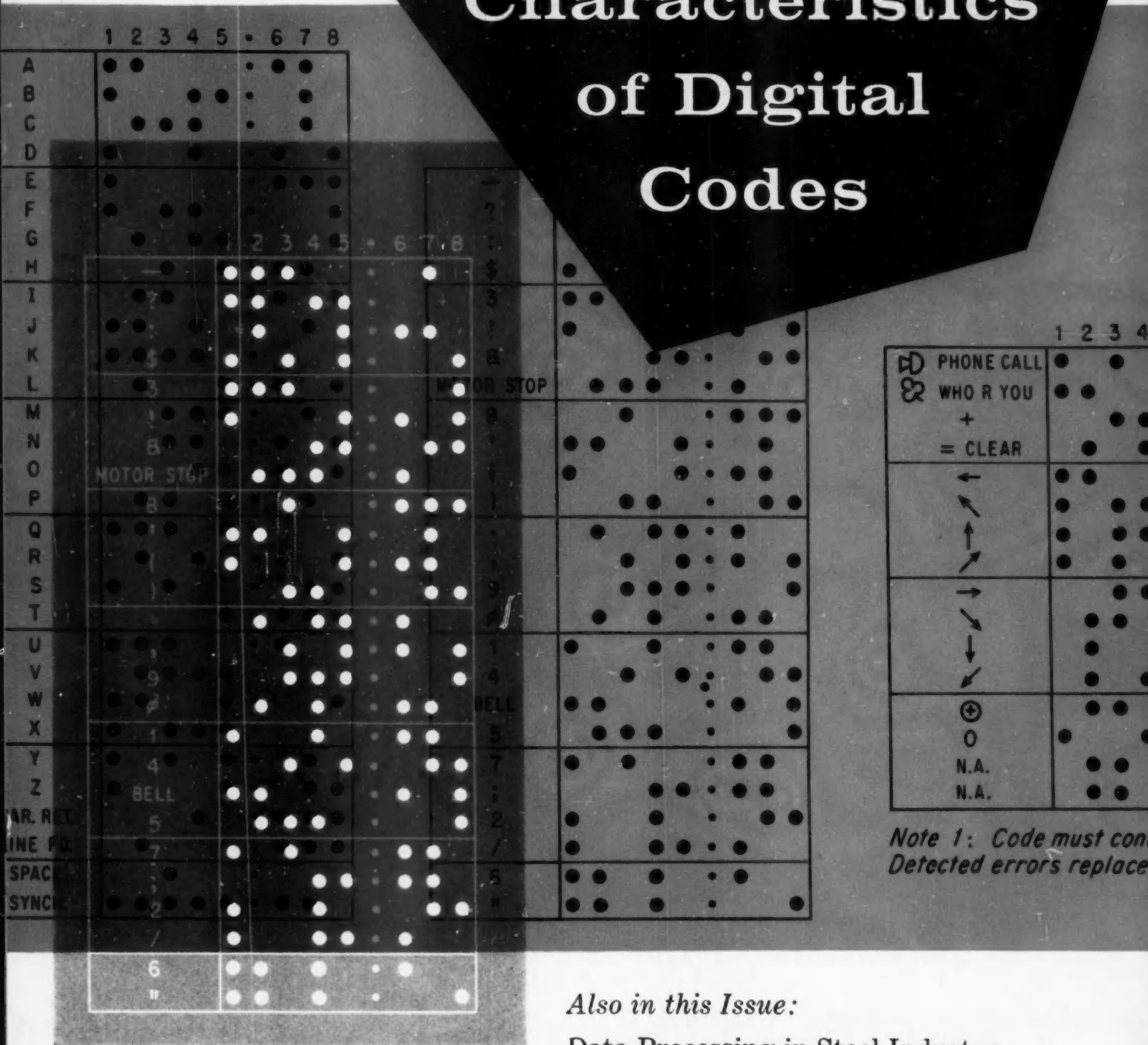
INSTRUMENTATION AND CONTROL SYSTEMS

A McGraw-Hill Publication

75 Cents

DECEMBER 1959

Characteristics of Digital Codes



Also in this Issue:

Data Processing in Steel Industry

Updating Surge Vessel Control Systems

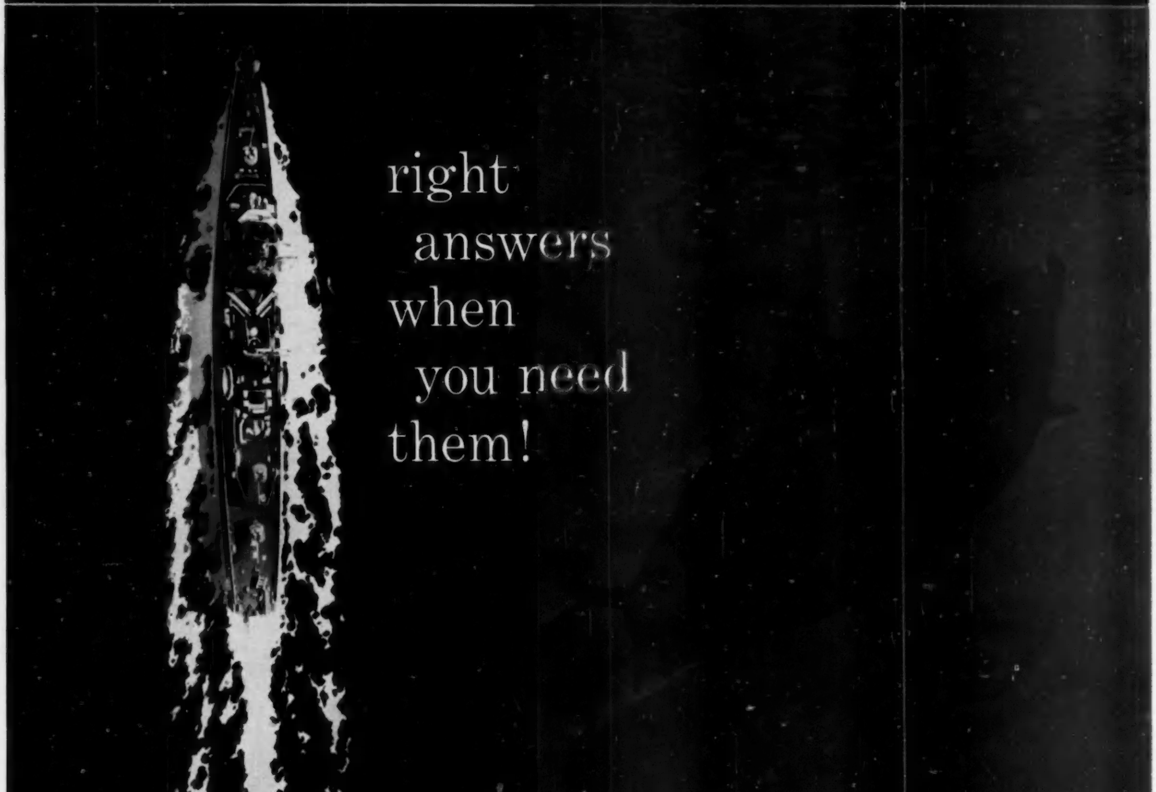
How They Keep Thor Operational

TODAY'S ANTISUBMARINE
WEAPONS CONTROL COMPUTER

THE TIME: *Early 1940.* **THE ACHIEVEMENT:** *A small, compact ballistic computer for the U.S. Navy.* **THE RESULT:** *The beginning of Librascope's leadership in the design, development, and production of weapons and navigation control systems and components.*

Today, Librascope-designed and manufactured electronic and mechanical equipment for the MK 113, MK 111, MK 110, MK 107, and MK 105 underwater fire control systems include computers, attack directors, torpedo and missile angle solvers, attack plotters, depth plotters, position keepers, target motion analyzers, stabilization computers, roll and pitch computers, and various indicators and control instruments. ■ Librascope's simulation laboratories provide the Navy with a means for testing and analyzing the performance of equipment under "real attack" conditions. In the field, our engineers assist in the maintenance and improvement of Librascope systems.

SHIPBOARD COMPUTERS



COURTESY NBC-TV FILMS' "THE SILENT SERVICE"

For information on career opportunities at Librascope, write Glen Seltzer, Employment Manager.

LI 9-8

Librascope's experience creating new concepts in computer—control systems for both military and industrial use can be accurately applied to your specific needs. ■ For detailed information and solutions to your computer problems, write...

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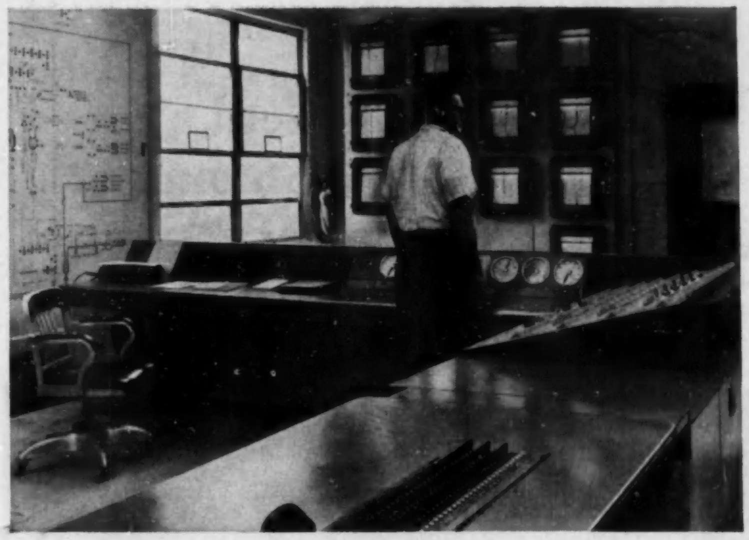


In operation since February, the L&N computer gives Carolina Power & Light Co., the desired generation loading pattern on five of its major plants for strict incremental loading, or modified economy loading. The computer can also be used to study anticipated operating problems and their effects on the cost of operating the system while the load control is still functioning.

Carolina Power & Light Co. closes the control loop with new L&N dispatch computer

New L&N "Desired-Generation" Computers Now Operating On Six Major Power Networks

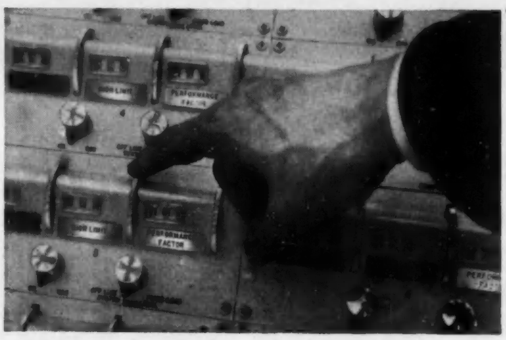
Like so many utilities, CP&L's steep growth curve of the past ten years is exceeded only by expansion estimates for the next ten. To ensure that system operation remains economical and smooth during rapid expansion, CP&L now uses an L&N Desired-Generation Computer-Control system for automatic control of better than 90 per cent of generation on its major (eastern) operating area. The new control encompasses telemetered values from five tie points and automatic allocation of generation changes among five major generating stations, including 14 units under control.

In moving ahead with an L&N system, CP&L is part of a growing trend, for within a year after installation of the first Desired-Generation Computer, six major American utility networks with a combined capability of 11 million Kw were using L&N computer-controllers.

Suggestion: you can help *your* system make the move to advanced automatic dispatching more objectively — and with confidence — by checking *results* first — the actual operating results being obtained right now from California to Carolina, from Connecticut to Florida (names on request). Then, talk with the men of Leeds & Northrup—or write to 4918 Stenton Avenue, Phila. 44, Pa., about a custom-engineered computer-control for your system—it pays.

Get results on your system with an L&N computer that:

1. *Automatically loads generating units on an incremental cost-of-power-delivered basis—includes incremental generating costs and transmission loss factors (transmission loss matrix optional).*
2. *Provides real operating flexibility: loads on any desired incremental, or modified economy basis, to meet prevailing system conditions.*
3. *Plots "on-the-spot" graphic answers to problems involving economy interchange, power-flow losses or anticipated loading patterns.*
4. *Derives a measured lambda value —incremental cost of power delivered—at all times.*
5. *Invariably adjusts generation in a direction that reduces area requirement.*
6. *Gives each unit a terminal destination.*
7. *Makes it easy to place units on control—just flip a switch—no synchronization required.*
8. *Provides safety margins: adjustable load limit settings are positive, and cannot be exceeded; maximum rates of control action are positive, adjustable, and cannot be overridden.*
9. *Costs less in the long run: requires no unit or governor modifications, goes into service after approximately two to four weeks installation procedure, gives positive assurance against overregulation.*
10. *Is easy to operate—gives any desired readout data, uses compact, convenient digital setters.*



Digital setters are just one of many operating aids built into L&N computers. Compact and easy to use, these setters enable you accurately to feed into the computer a wide range of input data: unit high and low limits, performance factor, type and cost of fuel being used, etc.

LEEDS & NORTHRUP
"Over 400 automatic generation control installations"

A unique approach to problems of AUTOMATIC CHECKOUT and MONITORING

MSI — Monitor Systems Incorporated — is an autonomous subsidiary of Epsco, Incorporated . . . leader in the field of data control and a pioneer in the development and manufacture of automatic checkout and monitoring equipment. MSI offers technical talent of the highest calibre, backed by Epsco's long experience in this highly specialized field.

To these advantages is added another important asset . . . *concentration.*

MSI is an independent company with its own, entirely separate staff and facilities; it is not a department of a large organization competing for operational necessities with other departments. As a result, *all* the talent, *all* the research, design and productive effort are concentrated upon a single objective . . . the advancement of automatic checkout and monitoring systems technology for weapon systems and subsystems testing, aircraft pre-flight testing, nuclear reactor monitoring, process monitoring, component testing.

Current projects at MSI amply demonstrate the specific and tangible advantages that result from this unique set-up.

We are completely staffed at all engineering levels — ready to fulfill your automatic checkout and monitoring needs. Inquiries are invited in regard to your requirements.

MONITOR SYSTEMS INCORPORATED

Fort Washington, Pennsylvania

A subsidiary of Epsco incorporated

Control ENGINEERING

DECEMBER 1959

VOL. 6 NO. 12

Published for engineers and technical management men who are responsible for the design, application, and test of instrumentation and automatic control systems

Continued on next page

What's New in the Control Field

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Position and company connection must be indicated on subscription orders. Single copies, 75c, except $2 for September issue. U.S. and Canada: one year, $5. Foreign, one year, $15. Second-class postage paid at Albany, N.Y. Printed in U.S.A. Title registered in U.S. Patent Office.
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you are looking at the best UNIVERSAL COUNTER-TIMER

Presenting the new CMC 226B

and here's the proof...

ENGINEERED FOR THE USER

CMC's new universal counter-timer is human engineered to eliminate costly "cockpit trouble." Take a look at the clean, functional lines.

And inside, this tastefully styled instrument uses modular circuitry to simplify maintenance and cut weight. Nine tubes have been eliminated, lowering power drain and operating temperature and increasing reliability. Weight is only 40 lbs.

TECHNICALLY SPEAKING

Direct reading, 0 to 1.2 mc. Time interval, 1 microsecond to 1 million seconds. Period, 0 microsecond to 1 million seconds. Stability of 2 parts in 10^7, with an option of 5 parts in 10^8. Sensitivity 0.1 volt rms.

Three input channels. Automatic decimal point indication. Reads directly in kilocycles, cycles, or microseconds.

Three independent, continuously adjustable trigger level controls for full rated sensitivity at any voltage level between −150 and +300 volts.

Oscilloscope marker signal to speed start and stop trigger level adjustment for TIM of complex waveforms; trigger level adjustment for amplitude discrimination in frequency and period measurement. Drives the CMC fast printer and most other types of printers and data handling equipment.

DO ALL THESE JOBS PRECISELY DO THEM EVERY TIME

Measure frequency, time interval, period, phase shift, frequency ratio, rpm, flow, velocity, and many other basic physical quantities.

NOW THE PRICE

$1100 fob Sylmar, California. Rack mount $10 extra. 220 kc Model 225C with similar specifications, $840 fob Sylmar.

WANT MORE DATA?

Your nearby CMC engineering representative will be happy to arrange a demonstration and provide you with complete technical information. Or you may write Department 0812.

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22

unusual capabilities and stability

64 channels in 60"

On these two pages eight fully transistorized Model 850-1500P Preamplifiers appear actual size—each measures approximately 2" x 7" x 14½". In racks of eight, 64 preamplifiers take only 56" of panel space, and a blower unit another 4". Necessary power and chopper excitation is provided by a completely transistorized Model 858-500P Power Supply that mounts at the rear of each 8-preamplifier unit, so that no additional panel space is required.

INPUT CHARACTERISTICS
Input circuit guarded, floating, isolated from output, can be grounded. Input impedance 200,000 ohms min. (Preamplifier also available at extra cost with 4-step attenuator with gains of 10, 20, 50 and 100 and smooth gain control to reach any intermediate setting.)

BANDWIDTH
DC to 70 cps (−3 db).

RISE TIME
25 ms to 99.9% of steady state value.

OUTPUT CHARACTERISTICS
Floating, independent of input, can be grounded.
Capabilities: ±1 v across 300 ohms, DC to 70 cps
±1.5 v across 300 ohms, DC to 40 cps
Output impedance 100 ohms. Output is across 300 ohm internal load, shunted by internal 4 mfd capacitance. Part or all of this resistance and capacitance can be supplied externally, in any combination to suit your application.

LINEARITY
±0.1% of full scale output (2 volts)

GAIN
100 (10 mv input for 1 volt output). Preamplifier with gain of 1000 (1 mv input for 1 volt output) also available on special order. Gain stability ±0.1% for min. of 24 hours.

INPHASE REJECTION RATIO
120 db at 60 cps, 160 db at DC, with 5000 ohms unbalance in source.

INPHASE TOLERANCE
250 VDC, 220 VAC

NOISE
2 uv peak-to-peak referred to input (measured over DC to 100 cps). Noise plus ripple for full scale signal not to exceed ±0.1% of signal (measured wide band-ripple is 880 cps).

DRIFT
±2 uv referred to input, at constant ambient temperature, after 30 minutes' warm-up. Input drift temperature coefficient ±0.2 uv/°C, max.

OVERLOAD RECOVERY
Preamplifier recovers from fully blocked condition within 20 milliseconds after removal of signal. 10 volts of signal at input will not damage preamplifier.

POWER REQUIREMENTS
Each Preamplifier requires 2.5 watts; Model 858-500P Power Supply handles up to eight Preamplifiers.

New Data Preamplifier model 850

$462.50
per channel, complete

Each Model 850-1500P Preamplifier costs $400, each Power Supply for every eight Preamplifiers, $500. Consider the substantial savings over equipment with comparable specifications — when economy "per channel" is multiplied by the number of channels you're using. (All prices are F. O. B. Waltham, Mass., within continental U. S. A.)

What distinguishes this data preamplifier from others is *not* its specifications *alone*—but the *combination of this performance with high reliability, practical cost* and *small size.* Together, they make the Sanborn Model 850-1500P the logical choice for data processing systems in which tens or hundreds of channels of information must be handled.

Completely transistorized, the 850-1500P is designed for amplifying low level inputs such as thermocouple, strain gage and resistance bridge outputs. Typical outputs include digital voltmeters, tape recorders, scopes and other readout devices.

Complete engineering data and application assistance is available from Sanborn Company. Contact your nearest Sanborn Industrial Sales-Engineering Representative, or write the main office in Waltham, Mass.

-1500P

SANBORN COMPANY
INDUSTRIAL DIVISION
175 Wyman St., Waltham 54, Mass.

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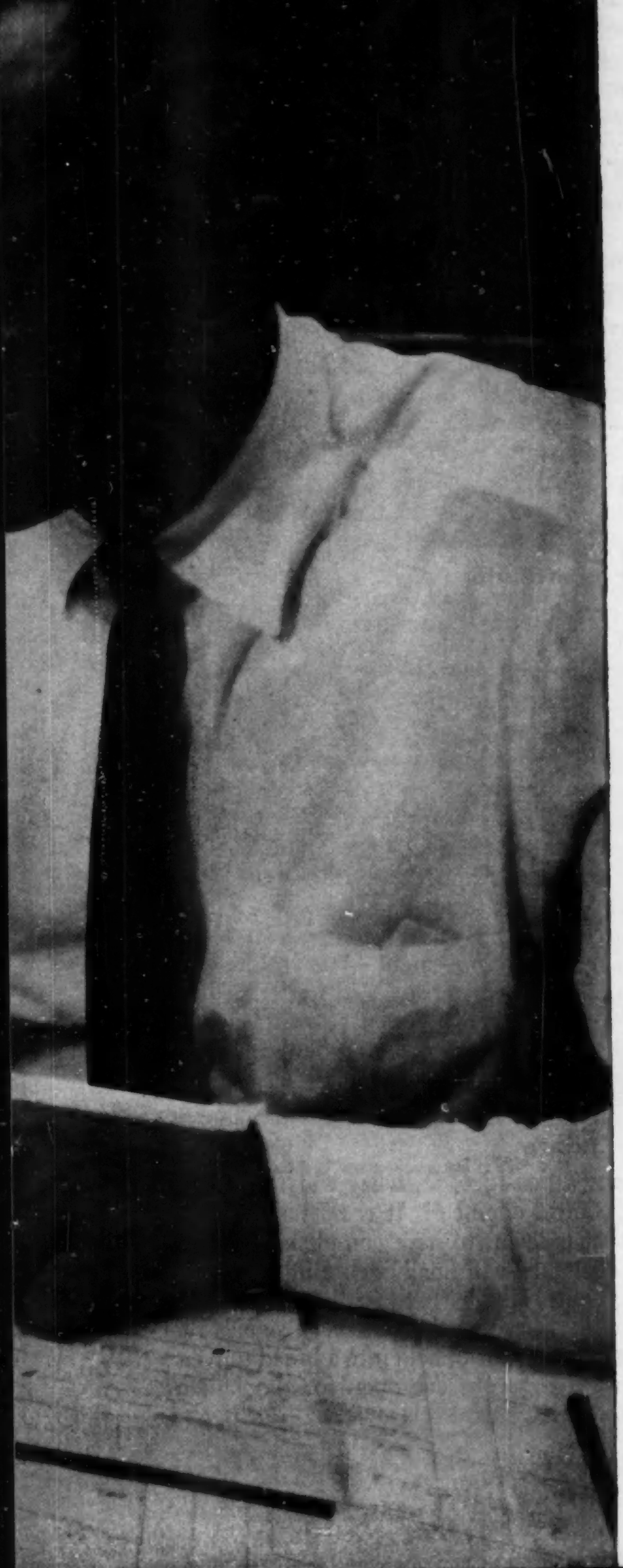
x = ωT/2 = 2πfT/2

announcing the new

IBM® 1620



first solid state engineering computer in the low-price field

Here is a new and powerful stored program, desk-size computer designed to bring more computing ability to engineering problems at low cost.

Transistorized throughout, the IBM 1620 is the only solid state, core-storage computer in its price class.

Easy to learn—easy to operate—easy to communicate with—this powerful computer relieves engineers from routine calculations—frees them for creative tasks.

Data is fed into the 20,000-digit magnetic core memory of the 1620 via punched paper tape. Alpha-numeric output is printed at the console typewriter in desired format, under stored program control.

This new computer with its two-address instruction format and variable field length, gives you up to 50% more storage capacity than a fixed word-length system.

All notations of input and output are in the decimal system. An unlimited decimal field and internal self-checking assure accuracy. A powerful two-address instruction format adds to the 1620's timesaving capabilities.

Programming is simplified through the use of IBM Fortran—a mathematical programming system which compiles machine instructions from algebraic and English language notation. A library of programs for standard engineering computations will also be part of the 1620 package.

Call your IBM representative—ask him to show you all the unique features of the IBM 1620. Like all IBM data processing equipment, this system may be purchased or leased.

BALANCED DATA PROCESSING

IBM®

Balanced Data Processing combines systems and services inseparably to produce performance in the best tradition of more than 45 years of IBM experience. It means more production per data processing dollar for you.

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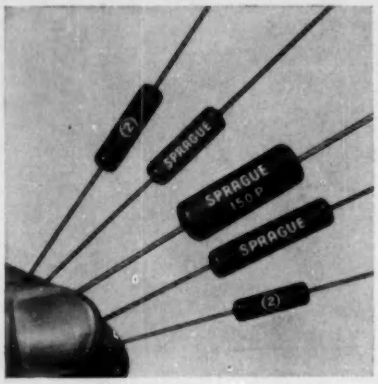

MINIATURE PROKAR® 'D' MOLDED CAPACITORS

—with a new 125 C dual dielectric and improved moisture resistance

Sprague's improved PROKAR 'D' Capacitors meet the need for *smaller* tubular capacitors capable of withstanding 125 C operation in military, commercial and industrial electronics.

Key to the improved design is a new processing technique for better humidity resistance and a new dual dielectric which combines the dielectric strength of the highest grade capacitor tissue with the effective moisture protection of plastic film, giving these miniature units high insulation resistance plus extended life at 125 C. The new Type 150P Capacitors are impregnated with the same exclusive high temperature organic material used in the original Prokar series which marked a milestone in molded capacitor development. *Capacitors may be operated at temperatures up to 125 C without voltage derating.*

For complete specifications on Type 150P Prokar 'D' Molded Capacitors, write for Bulletin 2300 to Technical Literature Section, Sprague Electric Co., 407 Marshall St., North Adams, Mass.

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SHOPTALK

Boy, do we need it!

Page 27 starts a story describing a new system designed to provide all-weather capability by positive control of air traffic. The writer, associate editor Lew Young, knows whereof he writes. Returning from a demonstration of the system, Lew, with other magazine editors, ran into bad weather in a Navy Super DC-3. The plane was stacked over Washington for 70 min prior to a landing at Anacostia Naval Air Station, and over Asbury Park, N. J., for 35 min prior to a final landing at Floyd Bennett Naval Air Station in Brooklyn. Staggering from the plane, Editor Young sat down to write his story, a strong advocate of positive control.

Reference material indexed

This issue contains our annual editorial index, page 186, to help you locate material published throughout the past year. A few copies of the this index are available on a first-come, first-served basis to those readers who want a copy for central indexing purposes. We hope, though, that you're all taking advantage of our perforated pages so that you can enter articles of particular interest into your own file.

Britain's regular contributor

Hitting CtE's pages for the third consecutive month with his root locus articles is Britain's Ted Jawor (see page 124 for his latest contribution). Now a senior member of Evershed & Vignoles' research department in London, Jawor came to Britain from Poland via France in 1940. His war service with the Polish Air Force based on the islands came to an abrupt end when he was taken prisoner after being shot down while ferrying arms to Europe's underground resistance movement. After the war and an EE degree from Glasgow University, Ted started at Evershed designing process equipment. When he switched from design to process theory, Jawor became one of the first participants in Cambridge University's post-graduate control engineering course.

Peering into the future

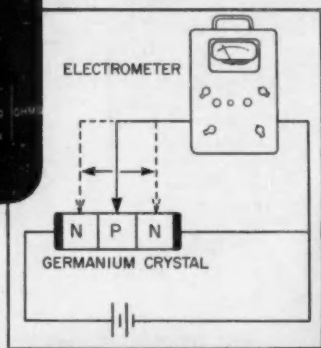
January 1960 starts a new decade; what will this decade bring forth for the control engineer? It is possible that the control field, now that it seems to have completed the gathering of its diverse elements, will finally gel. But Editor Bill Vannah will give 1,000 to 1 odds that just the opposite will happen. He sees technical, economic, and social signals that point to an expansion of the control field into a broad universe of automatic systems. Keep your eye open for the January issue where Vannah will lay out his bets.

LOOK

what one instrument will do!

MEASURES

VOLTAGES from 0.5 mv to 10v
CURRENTS from 0.005 $\mu\mu$a to 1 ma
RESISTANCES from 0.3 MΩ to 500 MMΩ

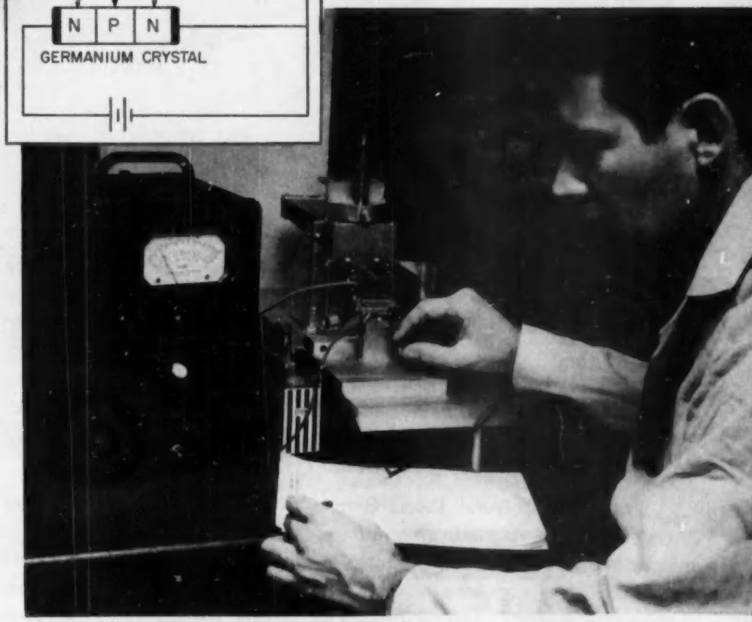


and Also Serves as a D-C Amplifier to Drive Oscilloscopes and Recorders

TYPE 1230-A D-C AMPLIFIER AND ELECTROMETER $440

- True direct-coupled amplifier design — no choppers, vibrators, or reeds to give mechanical trouble or get out of adjustment.
- High input resistance: 100 mega-megohms — does not load down sensitive circuits. Input resistance can also be set by switch to other values from 10^4 to 10^{11} ohms.
- Reliable operation even under conditions of high humidity — insured by silicone treatment of the electrometer tube's input and use of teflon insulation throughout input circuit.
- Electrometer stage protected against physical shock, ambient light effects, dust and random electrostatic fields.
- Guard point provided for three-terminal or ungrounded resistance measurements.
- High instrument stability — careful selection and aging of components, and shock mounting insure maximum instrument stability.
- Switch position provided for checking instrument's high-value internal resistance standards in terms of its lower-valued wire-wound standards.
- Constant low voltage across unknown (9.1v) — no need for voltage coefficient corrections when making high resistance measurements.
- Output for recorders

Write for complete information.



HOW IBM "MAPS" GERMANIUM CRYSTALS

IBM uses the G-R Electrometer to measure surface potentials and "sharpness" of PN junctions of germanium crystal specimens. A pointed tungsten whisker is "hopped" along the crystal surface by a micrometer drive, while electrometer readings are made at precise intervals. The G-R Electrometer meets the requirements of this application because its input resistance of several hundred megohms exceeds the contact resistance, it has the ability to measure millivolts as well as volts, and it also can drive an X-Y recorder.

GENERAL RADIO COMPANY

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LOW MAINTENANCE

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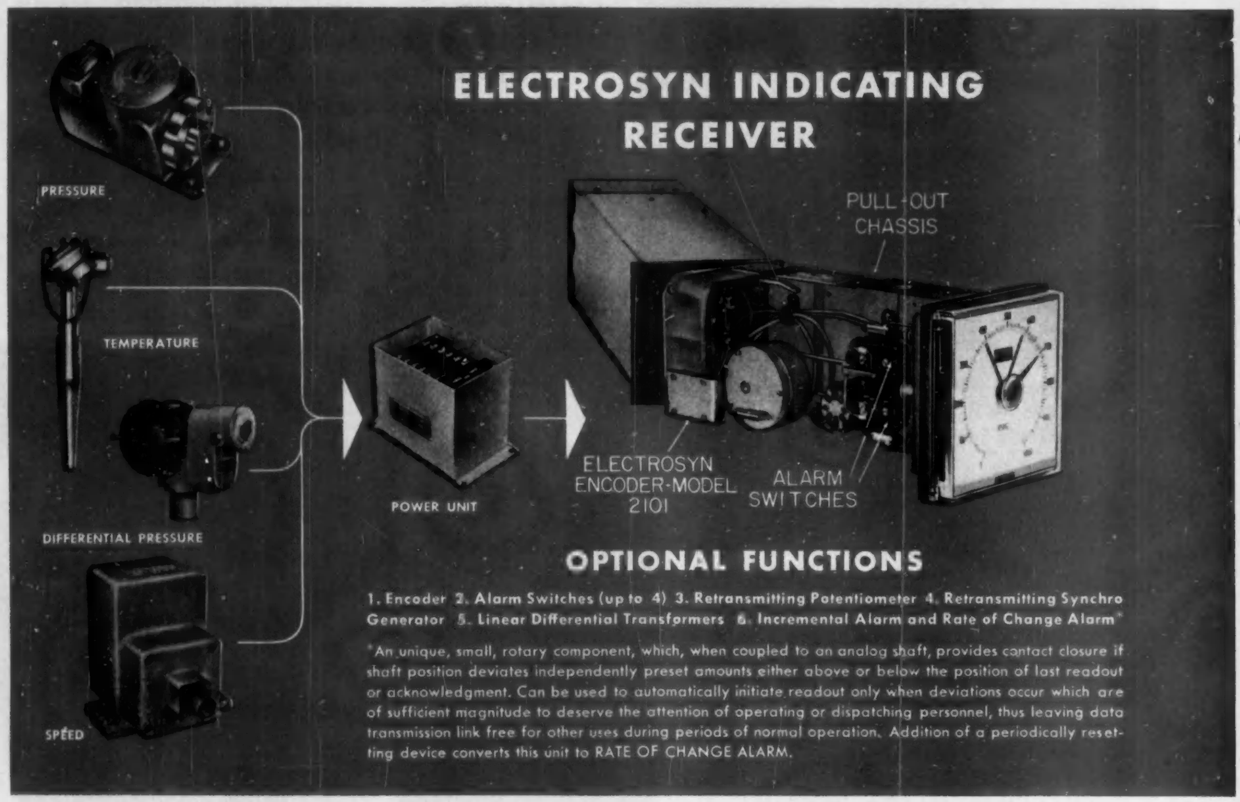
PROCESS and TELEMETRY Instruments and Components



Norwood Controls' ElectroSyn is a highly flexible, rugged electro-magnetic system for a wide range of applications in the chemical processing, atomic power, natural gas and petroleum transmission fields. It is designed to measure, indicate, record (including analog to digital conversions), or control a wide range of process variables. (Pressure, differential pressure, flow, level, temperature.)

Error signal is amplified by a magnetic servo-amplifier (which can be located up to 4 miles from transmitter). Signal voltage is compared with output from a servomotor driven feedback ElectroSyn Signal Generator. Pointer on indicator turns until signal and feedback balance and then entire system ceases to move until next transducer signal change.

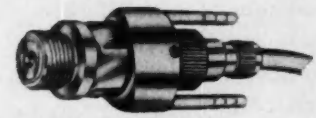
Also available as alternate systems: transistorized servo-indicator which performs same functions as magnetic amplifier system (illustrated above) and a low-cost meter readout system for either pressure or differential pressure when only indication of the variable is required.

These three systems offer a price range in keeping with the economics of most any application.

Write for ElectroSyn Bulletin B258C

NORWOOD CONTROLS

STRAIN GAGE
PRESSURE TRANSDUCERS

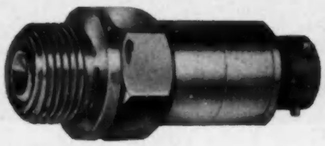


Models 108, 109 and 110

Model 113

WATER COOLED PRESSURE TRANSDUCERS

Models 108, 109, 110 and 113 water-cooled, high frequency transducers for pressure studies under very high temperatures. Can be exposed to gas temperatures above 5000 F without damage. All-welded construction for any applications, including highly corrosive liquids and propellants. Ranges: 0-500, 0-1000, 0-2000, 0-3000 and 0-5000 psi.

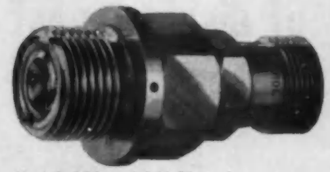


Model 111A

AIRBORNE PRESSURE TRANSDUCER

Specially constructed unit with features designed for high altitude flight service applications, such as 1000 volt insulation of electrical components for proper performance with vacuum ambient.

- High frequency response: flat from 0-20,000 cps.
- Bonded strain gage (rugged, low inertia, high stiffness) sensing element.
- Adaptable to virtually all strain gage amplification and readout equipment.
- Widest range of any pressure transducers on the market: ranges 0-25 to 0-100,000 psi.
- Widest temperature range: 0-250 F with air-cooled transducers (0-800 F with Plastics Transducers); 0-5000 F with water-cooled transducers.
- For both dynamic and static measurements without special equipment (which is required with crystal-type transducers). Ideal for internal combustion and rocket engine studies and pressure measurements in various high temperature processes, including plastic extrusion.
- Silver soldered or, for corrosive applications, all-welded catenary diaphragms.
- Insensitive to humidity (unlike crystal-type transducers).
- 2-arm 4-pin and 2-arm 3-pin bridges.
- 250 ohm 4-arm 4-pin standard and compensated bridges.
- Comprehensive, prompt repair service at minimum cost — no longer must you consider transducers expendable.
- High output signal.
- Custom designs for special requirements.



Models 101 and 102 (2-arm), 111 and 112 (4-arm)

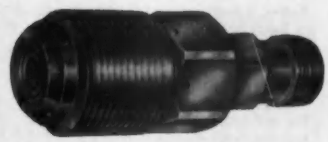
STANDARD PRESSURE TRANSDUCERS

Highly accurate, versatile transducers for dynamic pressure measurements requiring high frequency response (flat from 0-20,000 cps). Ranges from 0-100 up to 15,000 psi.

Model 103

MINIATURIZED PRESSURE TRANSDUCERS

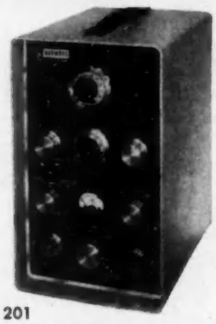
Miniaturized unit designed for applications where small size is a prime requisite. St'd threads 10-1.0 mm or ⅜"-24 are provided. High frequency response flat from 0-20,000 cps. Ranges: 1,000, 2,000, 3,000, 5,000 and 7,000 psi.



Model 104

HIGH PRESSURE TRANSDUCERS

For high pressure applications in blast analyses, gun barrel pressures, hydraulic high pressures, etc. Frequency response; flat from 0-20,000 cps. Ranges from 0-20,000 to 0-100,000 psi.



Model 201

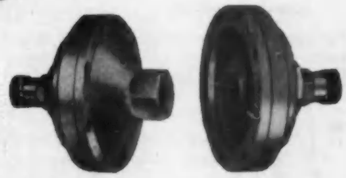
PRESSURE MONITOR

Amplifies 2-arm transducer output signal for oscilloscope display. Internal, manually-operated calibration provisions included, or may be equipped with external Model 203 Automatic Calibrator. Write for Technical Data Sheet A159-5.

Model 175

PLASTICS PRESSURE TRANSDUCER

New, one-piece, flush diaphragm, bonded strain gage type of pressure transducer, suitable for use in plastics extruders and other equipment where process temperatures approach 800 F and cooling of process fluid is not permissible. Standardized dimensions for extruder mounting.



Model 105 **Model 106**

LOW PRESSURE TRANSDUCERS

For pressure ranges 0-25 and 0-50 psig. Utilize same strain tube assembly as models above. May be used under conditions of extreme vibration as encountered in measuring shock waves in open air.

For detailed specifications write for Data Sheets A259 and A158-1: Norwood Controls Unit, Detroit Controls Division, 5900 Trumbull Avenue, Detroit 8, Mich.

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FEEDBACK

Letters tell a tale of the control community.

Of how American control people selected key U.S.A. literature for a library on nonlinear control. Of how, when asked by CtE, they gave copies of this literature to a former countryman now living in Italy. Of what the literature consisted. Ed.

A. F. Sperry, Skokie, Ill.—

I have somewhat changed my activity, from the theory of oscillations back to control problems. During 36 years since I abondoned the ill fated (for me at that time) control activity, the control field has grown up tremendously. Among its principal contributors there are two giants—the U.S.A. and U.S.S.R. From the U.S.S.R. I managed to get recently an enormous amount of material (which runs likely into something like 4,000 to 5,000 pages). From the U.S.A., I have at present less information, and now my mind is turned to correcting this.

A great many of my references to American literature (ASME, AIEE, and IRE) I got from Russian sources. Little by little I would like to collect my bibliography of the American references for future work.

I have a contract from the Office of Naval Research [to compile a study of nonlinear control theory]. The work is conducted at the University of Florence so as to be in closer contact with Professors Sansone and Conti who act as my mathematical adsivers.

N. Minorsky
Aix en Provence, France

In recognition of Dr. Minorsky's early contributions to the control field (CtE, May '55, p. 11), we agreed to obtain recommendations for the outstanding literature on nonlinear control, gather some of the literature, and send it to him. Ed.

To the Editor—

There is such a large number of recent references on nonlinear control theory which would seem to be of value; but I am enclosing a brief list which seems to me to summarize the recent work in this country.

1. *PROCEEDINGS, SYMPOSIUM ON NONLINEAR CIRCUIT ANALYSIS*, Polytechnic Institute of Brooklyn, Brooklyn, N. Y., 1956.
2. *SYMPOSIUM ON NONLINEAR CONTROL (1957)*, IRE Professional Group on Automatic Control; *TRANSACTIONS ON AUTOMATIC CONTROL*, July 1958.
3. *TRANSACTIONS*, AIEE, Vol. 75, Part II, 1956.
4. *TRANSACTIONS*, AIEE, Vol. 76, Part I, 1957.
5. *NATIONAL CONVENTION RECORD*, IRE, Part 4, 1957.
6. *A THEORY OF NONLINEAR SYSTEMS*, A. G. Bose, Technical Report No. 309, Research Laboratory of Electronics, MIT, May 1956.

John G. Truxal
Brooklyn, N. Y.

To the Editor—

So far as actual nonlinear systems go, there are three new books of interest: Ku, *Analysis and Control of Nonlinear Systems*—Ronald; Cunningham, *Introduction to Nonlinear Analysis*—McGraw-Hill; Cosgriff, *Nonlinear Control Systems* — McGraw-Hill. These books contain bibliographies that will enable one to assess the state of the art up to within two years ago. The one new major development I can think of since then is the area of self-adaptive controls.

John E. Gibson
Lafayette, Indiana

To the Editor—

Enclosed are copies of Part 4 of the 1957 *IRE National Convention Record* and the July 1958 *IRE Transactions on Automatic Control.*

E. K. Gannett
Managing Editor
Institute of Radio Engineers

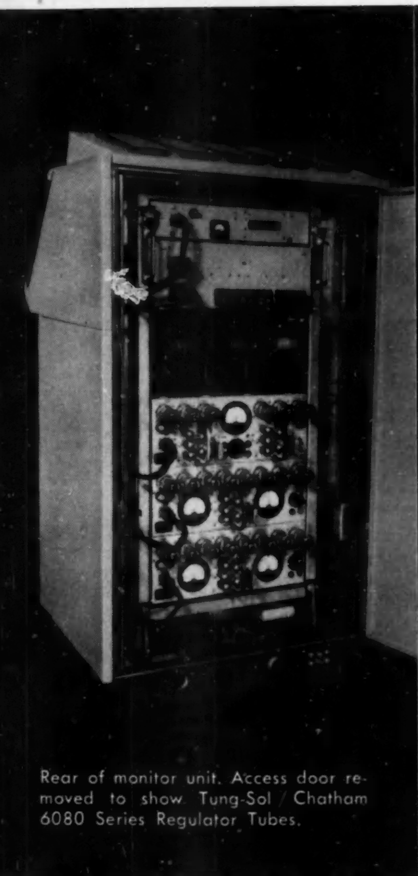
To the Editor—

Report No. 309 (A. G. Bose, *A Theory of Nonlinear Systems*) has been out of print for some time, but I have been able to locate a copy and am sending it to you.

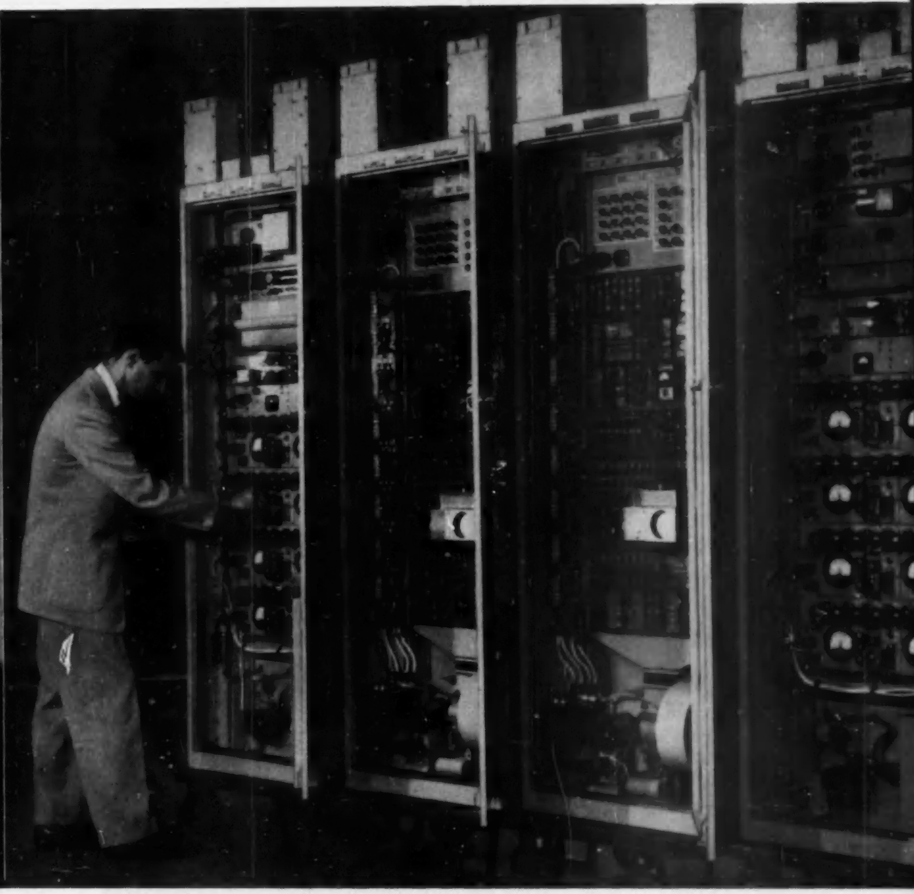
John H. Hewitt
Research Lab for Electronics, MIT
Cambridge, Mass.

Dr. N. Minorksy—

In another mail, you will receive a contribution of two books from the McGraw-Hill Book Co. recommended by Dr. John E. Gibson of Purdue University. We are sending these books with great pleasure and in recognition of the very significant contribution you have made to the nonlinear analysis field. Enclosed with this letter are a copy of the April



Rear of monitor unit. Access door removed to show Tung-Sol / Chatham 6080 Series Regulator Tubes.



Exposed view of power supplies show battery of Tung-Sol/Chatham 6080 Series Regulator tubes in Budd Lewyt's AN/FST-1 Transmitter.

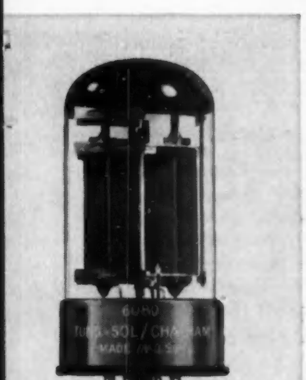
BUDD LEWYT links in SAGE system use Tung-Sol tubes to regulate power supplies

Defending America against air attack is the staggering job of SAGE. Daily, our radar network must locate, identify and track more than 30,000 aircraft in flight.

The Budd Lewyt CDT (Coordinate Data Transmitter System) helps do it automatically. CDT transmitters at unmanned Gap-Filler sites pick up, interpret, convert and then relay signals over telephone lines to CDT monitor units at SAGE Control Centers.

Handling 161,800 radar pulses per second, CDT verifies targets with 99.99% accuracy. Because this system must function with unfailing accuracy, Tung-Sol/Chatham 6080 Series tubes are used to regulate vital power supplies in both the transmitters and monitors.

Whether your equipment is a critical link in national defense, or a new idea for furthering automation in business or production, your Tung-Sol Applications Engineer can be a big help in the planning stages of your projects. Call him with confidence, because Tung-Sol impartially produces both tubes and semiconductors . . . assuring you better quality, efficiency and dependability in your product. We'd welcome the chance to prove it to you. Tung-Sol Electric Inc., Newark 4, New Jersey. TWX: NK193.



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FEEDBACK

1957 issue of the *Transactions* of ASME and copies of these articles from Control Engineering:

1. NONLINEARITY IN CONTROL SYSTEMS: AN INFORMAL APPRAISAL OF THE PROBLEM, J. Coales, February 1956, p. 55.
2. NONLINEARITY IN CONTROL SYSTEMS, PT. 1, BASIC PRINCIPLES OF NONLINEARITY, T. Stout, February 1956, p. 57 and PT. 3, DELIBERATELY NONLINEAR SYSTEMS, T. Stout, April 1956, p. 77.
3. NONLINEARITY IN CONTROL SYSTEMS, PT. 2, METHODS OF ANALYSIS AND SYNTHESIS, R. Kochenburger, March 1956, p. 82.

Ed.

Dr. N. Minorksy—

We are sending you, in another mail, some more material to add to your bibliography on nonlinear control. The material includes *A Theory of Nonlinear Control Systems* by Amar G. Bose, which was contributed by the Laboratory for Electronics of M.I.T., and the *IRE Transactions on Automatic Control*, July 1958, plus the 1957 *IRE National Convention Record, Part 4*. Dr. John Truxal of the Polytechnic Institute of Brooklyn recommended that we send them.

Ed.

To the Editor—

Many thanks for the literature and for your kind cooperation.

We have sold our property here and are moving to Florence where I shall work on the ONR contract with Professors G. Sansone and R. Conti on the theory of nonlinear control systems.

N. Minorksy
Aix en Provence, France

Who forgot the perforating bar?

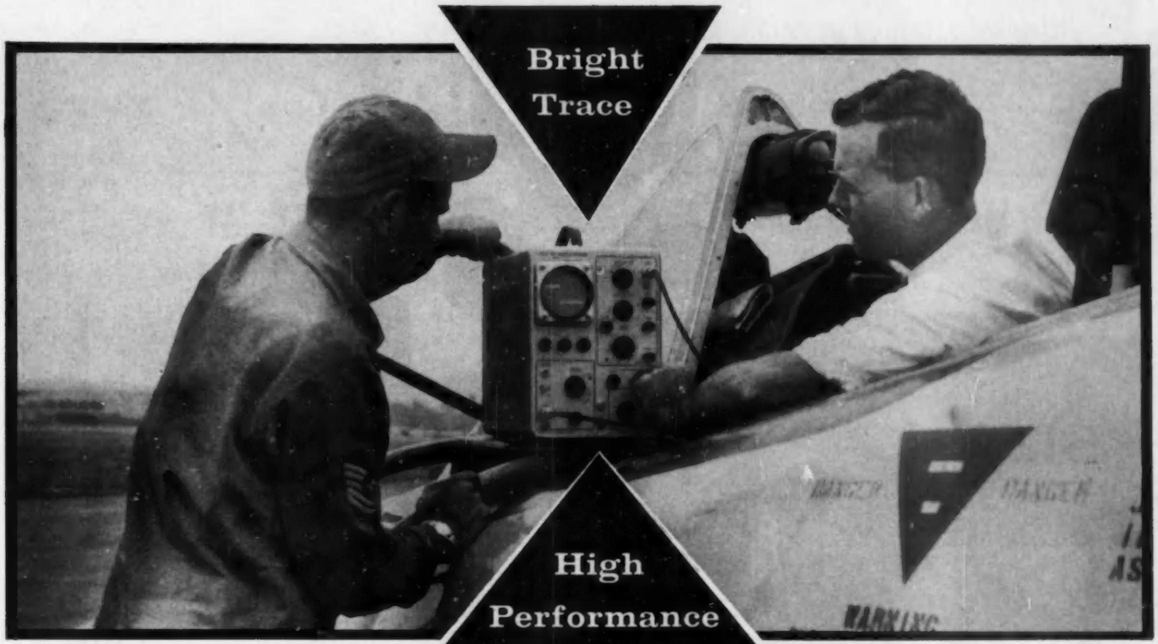
To the Editor—

I was clipping articles this evening for my file. The August issue with its perforated sheets brought a good measure of pleasant response to CtE's effort at service—all too soon dampened by the binding of the September issue, however.

If it is at all economically feasible to continue the practice of perforating your editorial material and layout, please do so.

Jerome Stone
Philadelphia, Pa.

In the hustle and bustle of producing the special issue, both the Editorial and Production Departments completely forgot about perforations. We intend to continue our policy of perforating and of placing ads in the feature section so that the articles can be torn out individually. Ed.



Courtesy Commander 337th Fighter Group, U. S. A. F.

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Risetime—0.035 μsec.
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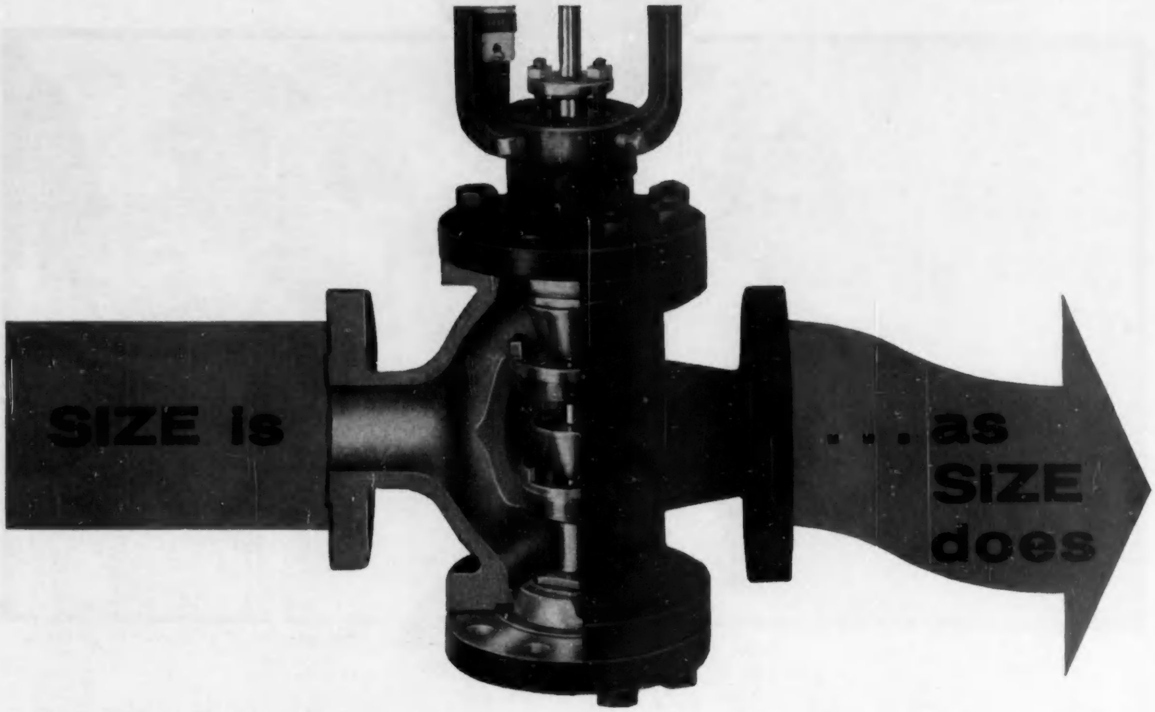


C_v is the thing to see

Take a hard look at fundamentals when you buy diaphragm control valves.

Valves of the same size won't necessarily deliver the same *amount* of valve performance. Flow capacity, not nominal size, is the dollar dimension to look at.

K&M valves provide the largest flow coefficient available. That means, in some cases, you can use the next smaller size at a worthwhile saving in dollars. In all cases, K&M's higher C_v produces a smaller pressure loss in the body; it places the flow restriction where it belongs . . . at the controlled inner valve.

Averaging 140% of cross-sectional pipe area K&M valves provide more space for fluids to flow . . . smoothly, freely with less turbulence.

Result—you get what you are really after . . . better controllability at lower cost.

Why not size up your control valve buying decisions on a real—not nominal—size basis?

Request Bulletin CV53

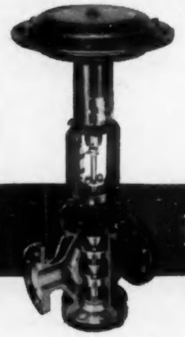
C_v COMPARISON TABLE

Valve Size	K&M	Valve B	Valve C
3/4"	10.9	8.4	8
1"	17.3	14.9	12
1 1/2"	39.1	33.2	28
2"	61	57	48
2 1/2"	97.7	71.0	72
3"	150	116	100
4"	219	197	165
6"	500	364	360

Based on the maximum Cv at rated travel through the valve body. From manufacturers' most recent slide rules or tables.

K&M

diaphragm control valves



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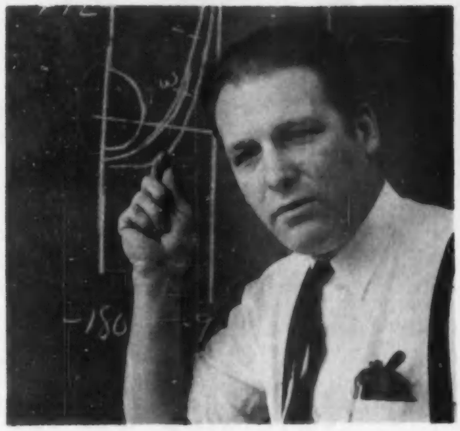
N. B. Nichols

a shirt-sleeved practitioner



Clutching a chewed cigar, his shirt sleeves rolled above the elbow, control engineer Nathaniel Nichols is likely to be working on problems so far apart that the answer to one might be couched in the theoretical terms understandable only to a PhD research scientist, and the answer to another might be empirical, something an instrument maintenance man could understand and use. Since his graduation from Central State Teachers College (now Central Michigan University) in 1936 with a BS in chemistry, Nichols has been exposed to a variety of control problems. Today, as vice-president and chief engineer, he's putting this broad exposure to work on the management team which is revitalizing instrument maker The Taylor Instrument Cos.

Nichols almost became a high school teacher. He was saved for industry by a scholarship at the University of Michigan and a summer job in the Physics Laboratory at Dow Chemical Co. The summer job introduced him to instrumentation and control. His first boss was Porter Hart, president of ISA in 1953, and he worked with such well-known control engineers as John Grebe and Ray Boundy, who is now head of Dow's research laboratories. Nicholas has been in the control business ever since.

At the University of Michigan he majored in Physics, earned his MS in 1937, and studied on until 1940, working for his doctor's degree. With his research finished, he left, intending to write his thesis later. But he never did. Today, he's adamant when the talk turns to thesis writing. His advice: stay in school until the last *i* is dotted.

In the summer of 1937, while on his summer job at Dow's Physics Laboratory, he designed a cathode ray polarograph to measure chemical composition. The development resulted in his first patent, and a paper he coauthored describing it won for him the American Electrochemical Society's young author prize in 1938.

When he left the University of Michigan, Nat (or Nick) joined The Taylor Instrument Cos. as a research physicist. There he collaborated with J. G. Ziegler on a study of process control that led to an often reprinted technical paper entitled "Optimum Settings for Automatic Controllers". In this the authors described an empirical method of adjusting controllers to obtain optimum results. Its popularity stems from the method's being easily understood by plant instrument men.

After World War II started, Nichols moved to the Radiation Laboratory at MIT where he was assigned for a six-month period to work in the Servo Laboratory with Dr. Gordon Brown. After this, Nick returned to the Radiation Laboratory as group leader of the servo group.

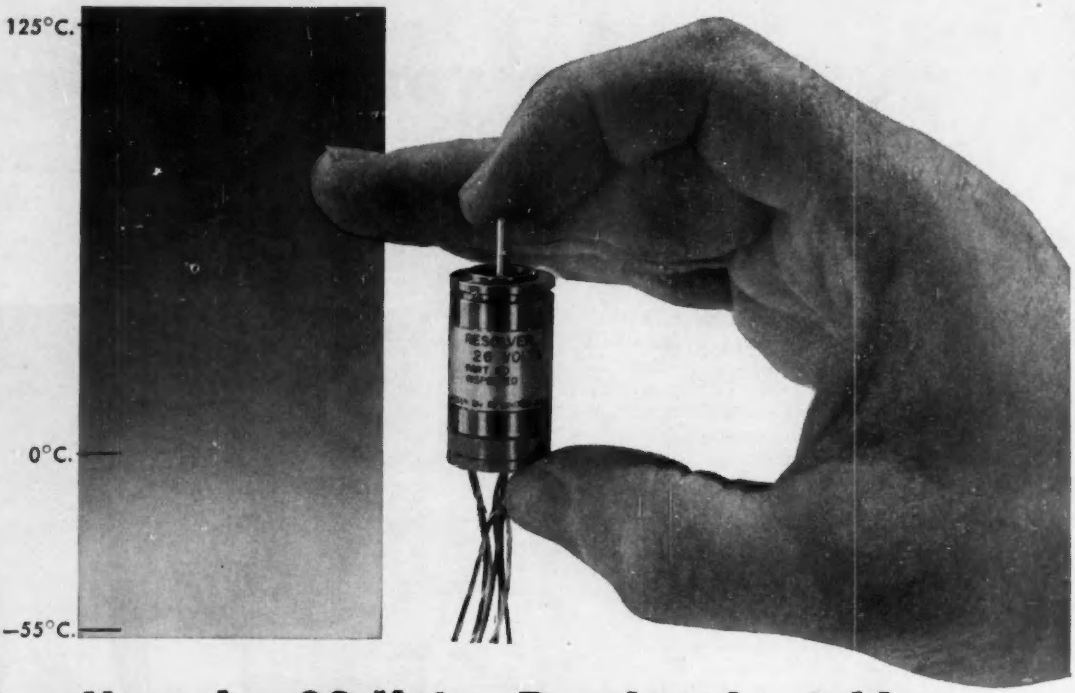
In the Radiation Laboratory he worked on such projects as developing a 2- to 3-hp. amplidyne drive for a Navy gun director and devising instrument servos for an analog computer in a ship stabilized automatic tracking radar system.

In 1945 Nichols left the Radiation Laboratory and returned to Taylor Instrument as director of research. But before he started work at Taylor, he took some time off to write his portion of the pioneering book *Theory of Servomechanisms* (edited by James, Nichols, and Phillips). Published in 1947*, it was the first book written on servo theory and it contained a description of how to use the Nichols diagram to study frequency response stability. Since then this plot has become a favorite tool of control engineers.

Nichols' early teaching training finally caught up to him in 1950. Enticed by an offer to set up a new course and facility in computing, he went out to the University of Minnesota as a professor of electrical engineering in 1950. He operated an analog and digital computing center, organized the first computer courses on the Minneapolis campus, and taught them. But when the Korea trouble started, industry—in the form of Raytheon Mfg. Co.—led him away from his short-lived academic life back to industry as manager of the Research Div. At Raytheon Nichols' main emphasis was on semiconductor research, though he did some looking at machine tool control too. He had worked his way up to the position of assistant vice-president when Taylor Instrument came to him again.

In 1957 he returned to Taylor for the third time, this time as chief engineer. He was elected a vice-president in 1958. Nichols is currently bringing Taylor back up to full strength technologically. His broad background—instrument design, process control, servo design and theory, computer technology, and semiconductors—is shaping the company's engineering direction, implementing it with his shirt-sleeved approach to control.

**McGraw-Hill Book Co., Inc., New York.*



New size 08 Ketay Resolver is stable over entire temperature range

This new Ketay Resolver provides stability over the entire temperature range of −55°C to +125°C. This is accomplished without the size and weight of compensating circuitry.

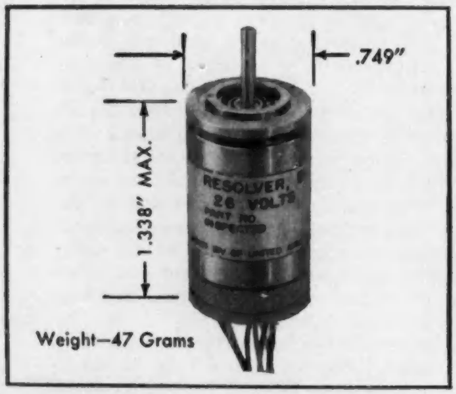
The Resolver has superior electrical characteristics:

- **High Input Impedance**—almost twice that of any existing unit.
- **Lower Phase Shift**—half that of existing units.

These features permit cascading twice as many resolvers with less degradation.

Resolver accuracy is now available in this small 08 size because of superior Ketay design. This Resolver meets or surpasses applicable military specifications for shock, vibration and humidity.

These typical specifications tell the story—



	At Room Temperature 25°C	MAXIMUM VARIATIONS Over Entire Temperature Range (Open Circuit) −55°C to +125°C
Input Impedance (ohms)	1010±10% /79°±1°	±10%
Transformation Ratio	1.059±1%	±1.0%
Phase Shift (lead)	6.0±1°	±2°
Null Voltage (total max.)	50.0 MV	±15.0 MV
Rotor Interaxis Error (max.)	±7′	±2′
Stator Interaxis Error (max.)	±7′	±2′
Functional Accuracy (max.)	±7′	±3′
Frequency 400 cps		
Input Stator		
Number of Phases		
Rotor 2		
Stator 2		
Voltage Rating 26V AC		

Please write for detailed specifications and outline drawings.

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Norden Division of United Aircraft Corporation
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Newsbreaks In Control

● NO MOVING PARTS IN PNEUMATIC COMPUTING ELEMENTS

Washington—Three engineers at the U. S. Army's Diamond Ordnance Fuze Laboratories have invented and demonstrated pure pneumatic computing elements with no moving parts. The units, initially developed by Dr. R. E. Bowles, B. M. Horton and R. W. Warren in their spare time, can perform amplification, feedback, digital computation, analog computation, normal mathematic functions, and memory. Basically the computing elements are a block of metal (or plastic) in which suitable passageways are provided. They are low cost, extremely rugged, reliable (it takes a bullet shot through the units to stop their operation), and have a long shelf life. The inventors see widespread use of the elements in both military and industrial applications: in standby computers in missile guidance systems, in control systems of gas pipelines and machine tools, and small special purpose computers. Initial demonstration of the units was so successful that DOFL has launched a large scale program in pure pneumatic systems. (For details see future issues of CONTROL ENGINEERING.)

● AUTOMATIC FLAME IONIZATION DETECTOR

Melbourne, Australia—Automatic flame ionization detector can identify impurities as small as one million-millionth gram in impurities. Developed by the Central Research Laboratories, Imperial Chemical Industries of Australia and New Zealand Ltd., the device works with a gas chromatograph. When gases leave the chromatograph column, they pass through a tiny opening like the needle of a hypodermic syringe and are burnt below a metal gauze. The flame closes a circuit. As the gases burn, particles of molecules are ionized, and the resistance varies according to the type of gas burning. Originally developed to anaylze etheylene gas, ICI is now using the instrument in other applications.

● DIGITAL CONTROLS AT INLAND STEEL

Chicago—Inland Steel will use natural gas to atomize the fuel in open hearth furnaces at its East Chicago, Ind., works for the first time. Superheated steam previously had been used. GPE Controls has designed a special digital control system to facilitate the changeover. An Inland Steel production man expects the use of natural gas will mean a considerable saving and better control of processing. For one thing, natural gas costs less on a Btu basis than oil. In addition, the sulphur content of the oil used has been increasing, and sulphur is undesirable in the open hearth. A next step might be the inclusion of a digital computer to program the cycling of the open hearth for the operator in open loop fashion.

● HIGH SPEED LARC AIMED AT BROAD APPLICATIONS

New York—Remington-Rand Univac Div., Sperry Rand Corp. will open up a new era in business data processing when it starts selling the newly completed Univac Larc Solid State Computer. Announced several years ago, Larc was developed primarily to solve atomic energy problems at the AEC's Livermore, Calif., installation. It can perform 250,000 additions or subtractions of 12-digit decimal numbers per sec, almost 200 times faster than any other computer in existence today. Now Rem-Rand sees other applications, primarily in business data processing. Typical example: preparation of payroll and labor distribution for a plant employing 15,000 employees could be done in 15 hours per month instead of 450 to 900 hrs as now required. One possible roadblock is high cost of Larc: over $6 million, rent from $135,000 a month.

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...are providing compact, lightweight, reliable actuation for critical flight control systems

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MOOG servoactuator packages are custom-designed for each application. These packages usually include an electrohydraulic servovalve, a cylinder-piston assembly and an electrical or mechanical feedback transducer. Various auxiliary control devices are often included within the actuator to reduce weight and improve over-all reliability.
MOOG can apply this package know-how to the solution of your actuation requirements.

Write for catalog 170.

MOOG SERVOCONTROLS, INC. PRONER AIRPORT, EAST AURORA, N. Y.

LEADING INNOVATOR AND PRODUCER OF ADVANCED ELECTROHYDRAULIC SERVOVALVES

New Improved Guidance Key to US Space Shots

As CtE went to press, Cape Canaveral Correspondent Dederer wired an exclusive report on a new guidance development. Because it will exert important influence on U.S. space exploration, we rushed it into print. The news: a miniaturized guidance system has been developed for launch-to-orbit control for the U.S.'s moon satellite.

CAPE CANAVERAL—U. S. interplanetary space probes scheduled for launch in December and early 1960 will have three separate radio controlled guidance systems. CtE learned this as the National Aeronautics and Space Administration readied a probe for an attempt to orbit the moon late in November. The four-stage vehicle, an Atlas-Able, will depend on a conventional Atlas guidance system for launching. Then, what enthusiastic NASA engineers call a "revolutionary" guidance system in the second stage will direct the probe out of the atmosphere. And a nearly identical system in the payload will guide the probe over the bulk of the 62-hr. finicky trajectory required to reach the vicinity of the moon. The moon probe scheduled for November will be the first U. S. shot which will carry working guidance in the payload.

The Atlas-Able being readied for the lunar orbit represents the U. S.'s most powerful space punch to date. It consists of a complete Atlas missile, on top of which has been mounted an Able vehicle (a modified Vanguard engine). Next is a solid-fueled third stage rocket. The powered spherical payload sits on top of this third stage.

Just before ignition of the payload engine, four vanes in the payload surface will spring out and lock into place, producing a paddlewheel satellite. Sides of the paddlewheels are honeycombed with 8,000 solar cells that will convert sunlight into electrical energy to recharge the probe's chemical batteries.

The first stage guidance system, standard Atlas guidance built by the General Electric Co., has already been put through exhaustive tests during the proving of the Atlas missile. The new guidance system, developed by Space Technology Laboratories, was first environmentally tested in Explorer VI, the 142-pound paddlewheel satellite put into orbit around the earth last August. But it went along just for the ride, did no guiding in Explorer VI.

What makes the STL guidance system so startling, say Cape Canaveral space men, is the fact that it is small enough and light enough to fit in the paddlewheel payload. The part of the probe that will orbit the moon will weigh only 378 pounds, of which 240 lbs represent engine weight, and 138 pounds intrumentation and control.

Scientists are so enthusiastic about the STL guidance system that they say the previously considered "fantastically difficult" job of hitting the moon would now be "child's play". The same men feel that if the first Atlas-Able shot fails to orbit the moon and hits the lunar body instead, they'll consider the experiment a "bust".

Probably the key parts of both the GE and STL guidance systems are on the ground. The airborne portion's main jobs are determining information from which the ground crew can calculate where the probe is, and then taking control signals radioed from the ground and activating the gimbals of the Able engine or the hydrazine engine in the payload.

STL system relies on Doppler techniques (shift of frequency of radio waves as the transmitter moves) for much of the location information. It is a modification of the Azusa system of tracking. Range is determined by modulating the carrier frequency of the ground station with three low frequency sinusoidal signals. By measuring the phase shift of the sinusoidal modulation, ground crews can calculate the range of the probe.

In a special computer, velocity and location of the probe will be continually compared to what has been previously calculated as a proper trajectory to orbit the moon. The computer will calculate deviations and determine what control signals shall be radioed to the probe to put it back on course. To do this an airborne transponder is interrogated by the ground guidance station. After the computer calculates steering signals they are transmitted to the probe.

To put the probe in orbit around the moon, scientists will fire the hydrazine-burning engine of the payload. This unusual engine can be fired in short bursts, has a thrust chamber at each end so that it can increase velocity or decrease it. Scientists expect to fire the "retro" chamber of the engine when the probe reaches the vicinity of the moon so that the moon's gravity can pull the probe into orbit.

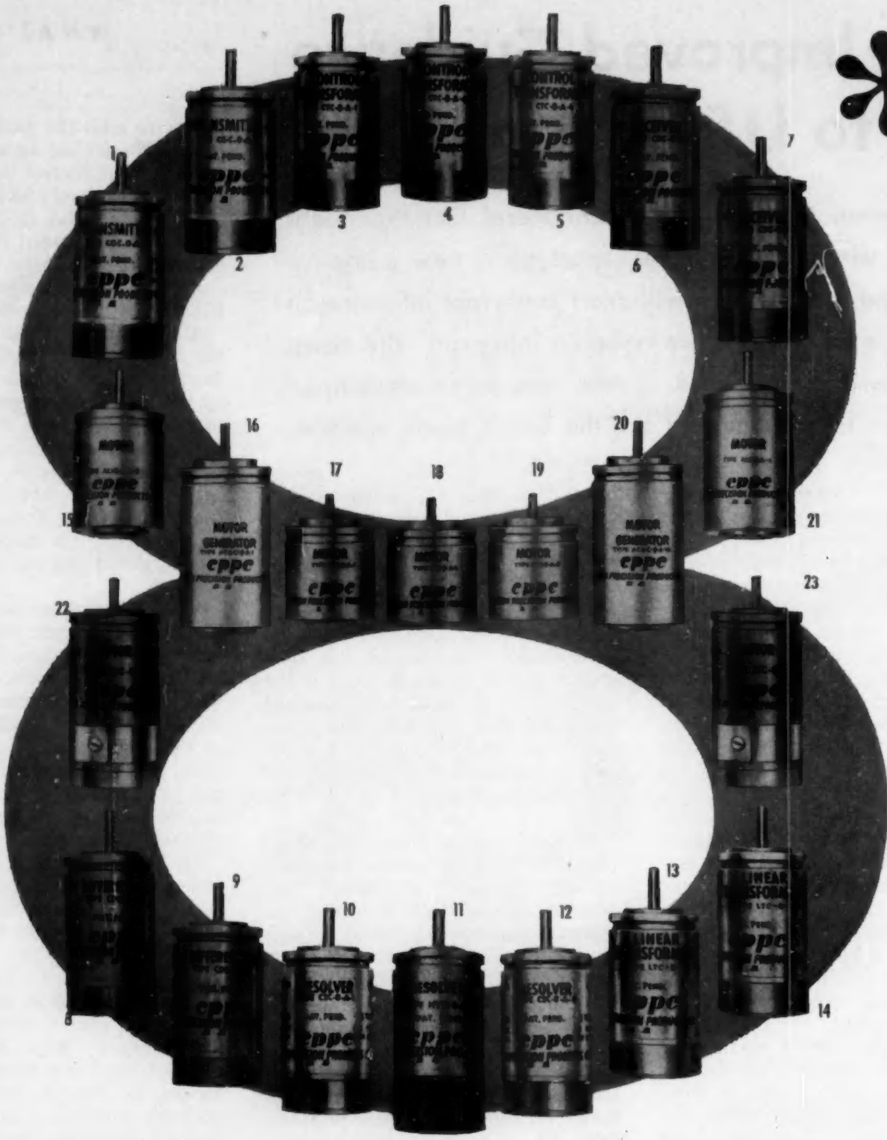
• **Instrumentation**—Many of the instruments for space exploration are similar to those carried by Explorer VI, the first paddlewheel satellite. A 2½-lb television scanner working in the infrared region will store photos of the moon's hidden side and play them back on command. The photos will be reproduced in a manner similar to the playback of a facsimile transmitted by wire.

Other instrumentation includes: two magnetometers for magnetic field evaluation experiments, two micrometeorite counters to measure number of hits scored by meteorites, a device to measure three levels of cosmic radiation, and an aspect indicator to measure electric current in space. STL engineers have also come up with a unique but simple method of keeping the temperature of the probe relatively constant. Cells, shaped like Maltese crosses, are mounted on spindles on the outer skin of the probe and connected to a simple thermostat which is located inside the probe. On one side of each cell is a dark-surfaced titanium foil decal which absorbs heat; on the other side, a white side which reflects heat. If the temperature inside the probe rises, the thermostat moves the cells so that the white sides reflect heat from the probe.

• **Turkey shoot**—As CONTROL ENGINEERING went to press, NASA was planning a lunar satellite try for Thanksgiving day.

The Atlas-Able moon missile will pave the way for a probe towards Venus sometime in December. NASA will use the Atlas-Able vehicle and its three radio controlled guidance systems for that shoot too.

—Douglas Dederer



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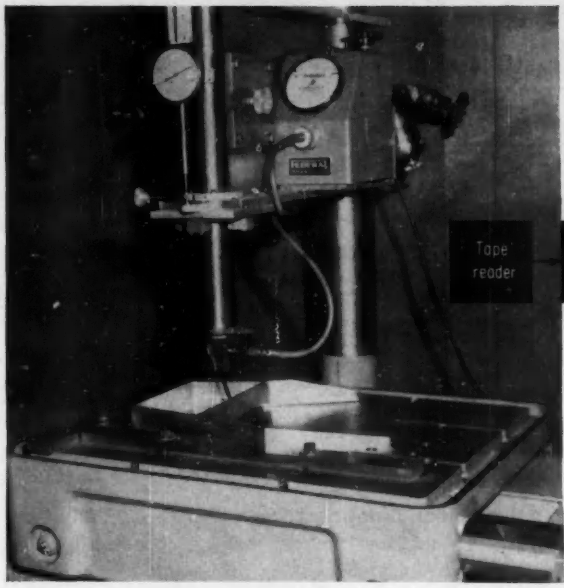

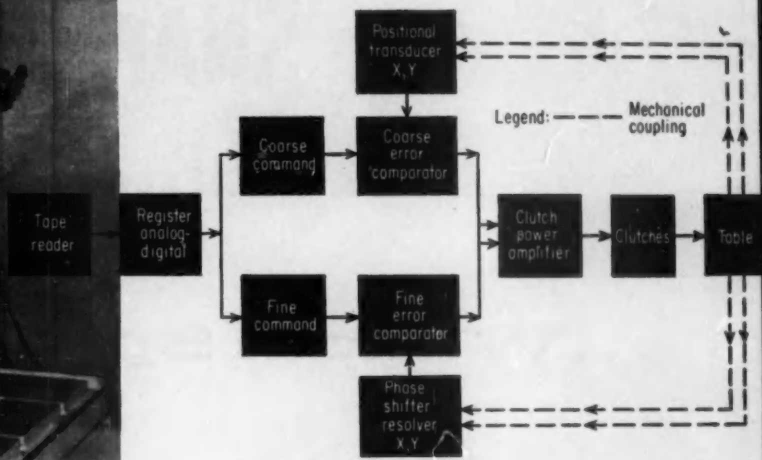

AUTOMATIC INSPECTION system checks out an aircraft part. Pneumatic gage at top right records deviations in horizontal measurements. Vertical measurements are made on the indicator at top left which records actual dimensions, rather than deviations.

Automatic Inspection by Machine Tool Control

LOS ANGELES—

To satisfied users of numerical control systems on machine tools, the next step in machine shop modernization–automatic inspection–is eagerly awaited. At Boeing Airplane Co., for example, numerically-controlled tools are cranking out parts at a frantic rate, but an army of inspectors surrounds the machines checking the end results. Last month Stromberg Carlson introduced one approach to automatic inspection. S-C has refined its 202 point-to-point positioning system so that it selectively inspects high quantity production parts–measuring as large as 14 in. x 18 in. x 10 in.–to accuracies of 0.001 in.

The new machine, said an S-C spokesman, should reduce mechanical inspection time of typical parts by 75 percent. But it will not yet replace the human inspector. Instead, it is designed to assist him. The initial design, equipped with two-axis control and manual readout, does not recognize material identity, nor can it detect gross surface or machining errors outside inspection areas.

S-C's new inspector is punched-tape controlled, incorporates all three components of its parent Digimatic System (CtE, Feb. '58, p. 115), including keyboard, control console, and servo positioning table. The key addition, however, is a stationary air probe sensing unit, which measures extent of part deviation at each programmed inspection point on horizontal axes.

Vertical dimensions in this early model are measured by lowering a quill (arm) until a mechanical dial indicator makes contact with the part.

To program the S-C inspector, a clerk prepares planning sheets which detail consecutive points of inspection and specify dimensions at these part locations. Information from the planning sheet is then punched into a keyboard in decimal coordinates to produce the punched tape program.

• **Inspection order**–Key parts of the servo table are the base, cross-slide, and table. Y-axis motion results from movement of the cross slide relative to the base. X-axis motion stems from movement of the table with respect to the cross slide.

During inspection, the machine checks horizontal (X and Y) measurements first. The punched tape consecutively positions individual inspection points at the tip of the stationary deflection probe. If the point is exactly correct, the probe shows zero deflection. If the point is oversize or undersize, however, the probe indicates on a pneumatic gage the extent and type of deviation in thousandths of an inch.

To make thickness measurements, the operator first replaces the deflection probe with the mechanical dial indicator. The machines moves to the X and Y coordinates of the inspection point. When it reaches the inspection point and stops, the operator lowers the quill and takes a vertical reading. When a mechanical indicator makes contact with the part, it relates this position to table surface position in thousandths of inches. The human operator records the reading and raises the quill to allow the machine to move to the next point.

• **Manual operations**–With S-C's system the human inspector also has to rotate the deflection probe four times during the inspection process because the probe can measure in a single direction only. The rotation accommodates the change in direction of the table travel as it brings each of a part's four horizontal surfaces in contact with the probe.

The present model has a traverse speed of 100 in. per minute. Its absolute positioning accuracy is plus or minus 0.001 in. Repeatability is plus or minus 0.0002 in. Price $22,500.

–Michael Murphy
McGraw-Hill News

SNAP-LOCK Limit Switches

Actuate Two Circuits Simultaneously ...Without Special Linkage

The D-2400 series Snap-Lock Limit Switches with two normally open and two normally closed contacts permit making or breaking two individual circuits simultaneously. Mounting problems are simplified, special linkages eliminated and costs kept to a minimum.

Snap-Lock Limit Switches were originated by National Acme to meet the severe mechanical and electrical conditions imposed by all types of machine tools. The outstanding simplicity and ruggedness of these water and oil tight switches make them adaptable to the toughest heavy-duty assignments.

Four basic models with a wide variety of actuating levers will handle up to 5 amps, 600 volts, AC. For complete details, parts list, and scale drawings, write for Bulletin EM-5824.

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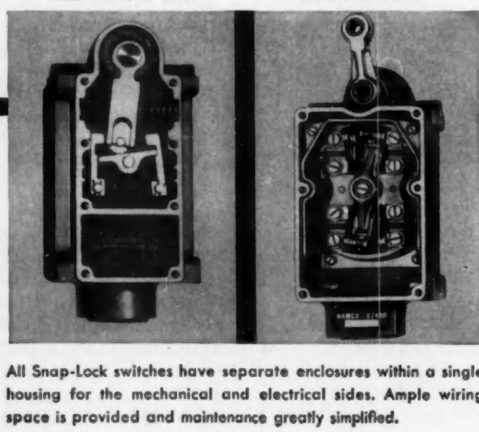
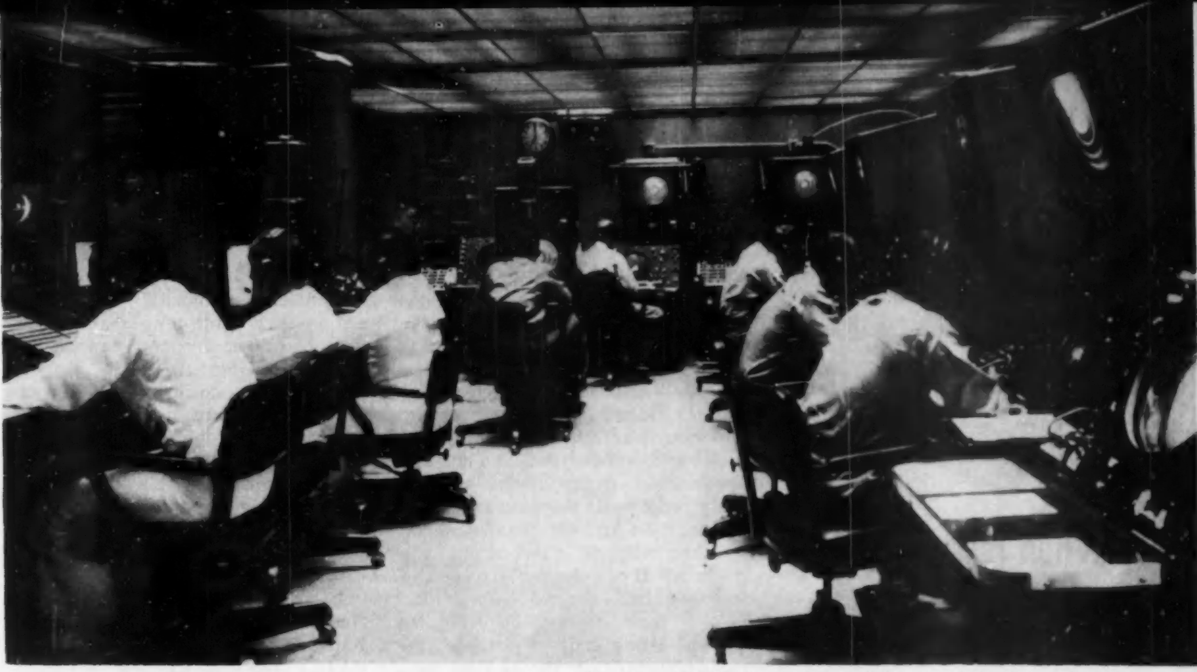


All Snap-Lock switches have separate enclosures within a single housing for the mechanical and electrical sides. Ample wiring space is provided and maintenance greatly simplified.



Oceana's RATCC. *Air traffic controllers sit at the left, radar operators at the right in blue room. SPANRAD viewers, which convert radar blips to TV pictures, have been placed above the consoles.*

Navy Speeds Landings with Positive Control

Radar control at a Navy base lands jet aircraft at a rate of one per minute in any kind of weather. The big question: will it work for civilian aircraft?

VIRGINIA BEACH, VA.—

Rendezvousing 35 miles from the Oceana Naval Air Station in a blustery rain storm, four Navy jet fighters on a training mission were picked up by the Navy's new Radar Air Traffic Control Center (RATCC) at Oceana. The planes peeled off under instructions from the ground, swooshed into a preassigned compass heading, and 10 minutes later all four were on the ground, taxiing towards their hangars. Meanwhile, 40 minutes away at the civilian Washington, D. C., airport, commercial airliners droned overhead, circling in the familiar stacking arrangement, waiting their turn to land. As much as 75 minutes passed before the last airliner in the stack landed.

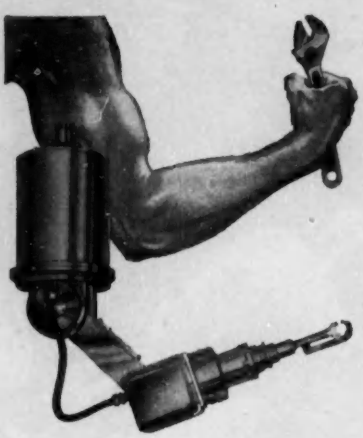
This contrast (a frequent one) demonstrates the big advantage of positive control of aircraft traffic. At Oceana, the Navy's prototype RATCC, positive control increased landing capability from 600 aircraft per day under conventional instrument control techniques to 1,500 per day with the new arrangement—in any kind of weather. Eventually, the Navy will have 17 RATCC's like the one at Oceana. Six are already in commission, though not yet equipped with the same electronic instrumentation.

At Oceana, positive control means keeping aircraft under radar surveillance continually and guiding a plane down verbally. To do this, the RATCC has three different radar sets. First, the center picks up aircraft with medium range (200 mile) radar; at about 50 miles a short range radar takes over; and finally a precision radar guides the aircraft from about 9 miles down to touchdown. Radar surveillance extends to an altitude of 60,000 ft.

Because the average radar operator can watch no more than five aircraft at a time, the Navy has backed up its radar plan position indicators (PPI displays) with a device called SPANRAD (Superimposed Panoramic Radar Display), built by Intercontinental Electronics Corp. Spanrad converts the radar picture to a television one, stores the location of the aircraft blips so that the operator need not keep their locations in mind continually, and permits superimposing "shrimp boats (plastic markers shaped like arrows which air traffic controllers traditionally use to identify aircraft on radar) on the viewed TV cast.

Although some pilot indoctrination helps instill confidence in the system, training is not necessary. The pilot only has to follow instructions transmitted from the ground as to compass heading, altitude, and airspeed. Flying the Oceana system is no different than making any other instrument flight rule trip, except that the contacts between plane and ground are more frequent in positive control.

• **Pilot to RATCC**—Operationally, here is how positive control works at Oceana. As an inbound aircraft (or flight of four aircraft) arrives within



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". . . you are now on final approach . . . you are now on glide path . . . you are now over touchdown . . . land aircraft . . ."

radio communication distance, the pilot contacts Oceana approach control. An approach controller makes out a flight strip on the aircraft, incorporating identification information, speed, altitude, and estimated time of arrival. He relays the latest weather and assigns an altitude to avoid conflicts with other traffic. Then the approach controller advises the medium range radar operator to look for the flight on his radar equipment and to advise when it is picked up.

On report of radar contact, the controller advises the pilot to contact Oceana radar on a given radio frequency. After contact is made, the radar operator puts the airplane on a compass heading so that it intercepts the Oceana approach position (approximately 36 miles south of the Air Station).

As the flight approaches the fix, the short range radar operator picks up the aircraft. When it reaches the fix, the radar man directs him to steer a certain heading and to begin his descent.

Ten miles from the airport, the aircraft is picked up by the precision radar operator. From this point, the pilot "flies the controller's voice":

"*You are now on final approach, do not attempt to acknowledge any further transmissions. If no communications are received for any five second interval while on final descent, pull up straight ahead and follow lost communications instructions* (previously given by short range radar operator). *You are now on glide path heading 050 degrees, adjust your rate of descent to hold on glide path.*"

The controller continues to guide the plane by watching the aircraft's position with respect to glide path and runway center line etched on the face of the scope.

And finally the pilot hears, "*You are over touchdown, land aircraft straight ahead, switch to tower for taxi instructions when you have slowed down, Oceana radar out*".

Using this system, Oceana has landed aircraft when the visibility was down to as little as a quarter of a mile.

Because there are three positions for each type of radar, three aircraft can be placed on final approach at the same time. Planes can then land at the rate of one each minute; in an emergency the system can land an aircraft every 30 secs.

• **For civilian aircraft?**—After watching positive control work at Oceana (watchers at a press tour saw an unexpected, better-than-average demonstration when one aircraft lost its communication system in the midst of its approach, had to follow the plane in front of it to make a landing), observers were convinced it works fine for Navy training and tactical operations. But the big question is still unanswered: will such positive control work with mushrooming civilian air traffic?

Even enthusiastic boosters of the Navy's system are dubious. For example, Commander W. E. Tucker, RATCC officer at Oceana, says probably not. He points out that radar will not pick up many of the small business aircraft that make up general aviation, the biggest, in numbers, chunk of aviation. In addition, many of these small planes have no radio, an essential piece of equipment to close the loop of positive control, and their pilots are not qualified to fly instrument flight rules. Finally, Oceana's air traffic is still small compared to such truly congested air spaces as Washington, D.C., New York, and Chicago.

The Navy system has no electronic data processing because it is not needed.

• **Means of positive control**—Still the Federal Aviation Agency is studying possible ways of exerting positive control. Radar, as used at Oceana, is only one approach. Another method is a system developed by Servo Corp., which pinpoints aircraft's position by tracking the radio beam an aircraft emits when it communicates with an air traffic center or tower. Loctracs, which Lockheed Electronic and Avionics Div. unveiled in October, is based on continuous automatic transmission of coded signals from a special transmitter in the airplane. Ground stations, located across the U.S. which would be divided into sectors, would locate the plane from these signals, then transmit position data to the nearest Air Traffic Control Center.

Just what method of tracking FAA will adopt, if any, is anybody's guess. But more and more aircraft specialists are reaching the opinion that positive control of all aircraft has got to come —it is only a question of time.

—Lewis H. Young

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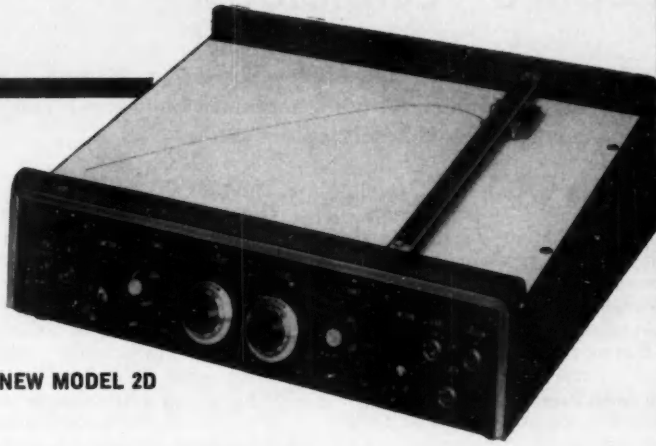

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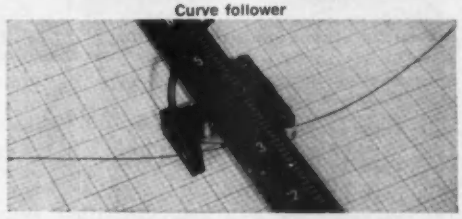
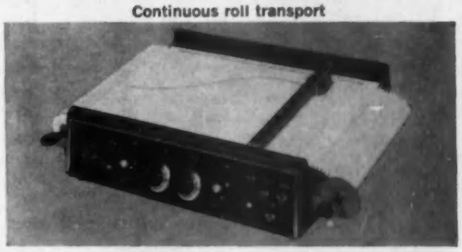


Continuous roll transport



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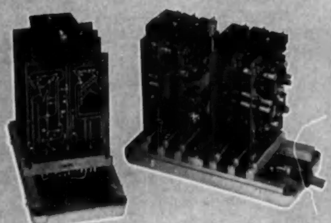

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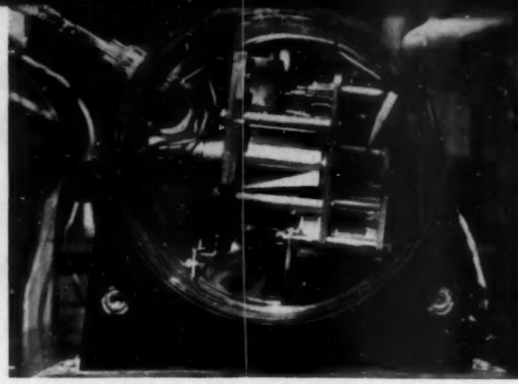


RCA's electronic camera *is designed for space age photography from satellites and space vehicles. Pencil points to reel of electrostatic tape upon which image is recorded instead of film.*

New Life for Photography in Space Technology

Satellite exploration calls for new instruments for measuring visual radiation, infrared, and ultraviolet. And it calls for new methods of recording the image.

NEW YORK—Space exploration is putting new life into the photographic instrumentation business. Normally leaning heavily on the entertainment aspects of photography, the Society of Motion Picture and Television Engineers offered up some rare listening matter to its 86th Semiannual convention in October. Sessions on Space Technology and Image Sensing heard papers that ranged from practical weather forecasting to pure scientific theory.

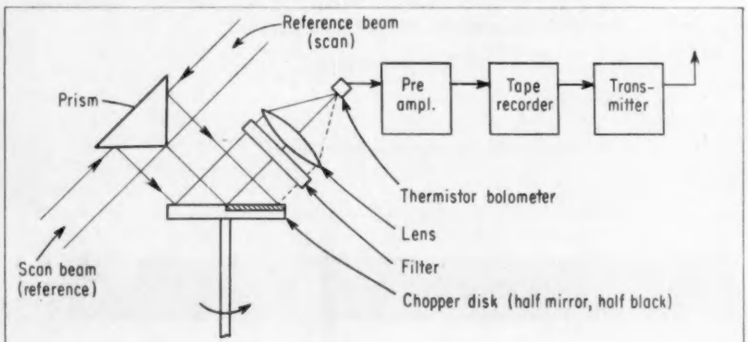
Instruments in space promise the weatherman a new dimension in his task of predicting weather. In one paper, D. S. Johnson, U. S. Weather Bureau, reported that because the earth's weather is determined mostly by conditions prevailing in the lowest 40 miles of the atmosphere, satellite observations for weather analysis require image sensors that can measure solar radiations reflected, or infrared radiations emitted, from the earth and its atmosphere.

One technique the weathermen feel is promising is the observation of clouds for distribution and type. Detecting clouds illuminated by sunlight, moonlight, and even starlight puts exacting requirements on sensors. For observations with solar radiation, Johnson said, the sensor has to be sensitive to the wavelength around 0.65 microns for optimum relative contrast between clouds and backgrounds.

• **Infrared viewing**—Geophysicists, as well as meteorologists, could dig out valuable information from infrared maps of the earth taken from satellites reported R. A. Hanel and W. C. Stroud of the National Aeronautics and Space Administration. Water vapor and carbon dioxide, which act as huge radiation filters, and clouds, which serve as a shutter, radiate energy proportional to their own temperatures and in the safe spectral bands that they absorb.

If a satellite were to carry infrared sensors which were sensitive to water

One channel *of the radiation experiment planned for Tiros satellite.*



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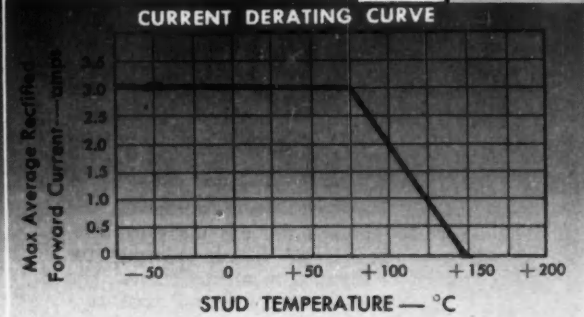

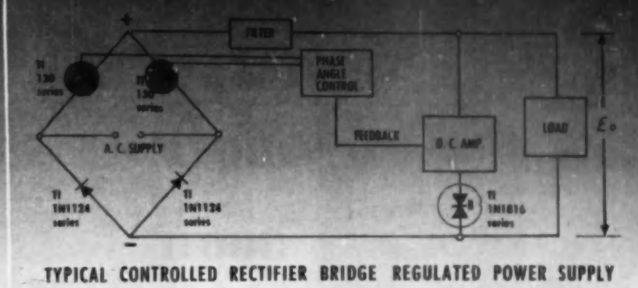

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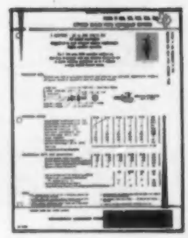
The TI diffused silicon P-N-P-N controlled rectifier has a third lead which controls current flow. A low 5-ma current fires the device which requires only 0.6 microsecond turn-on time. You get guaranteed PIV and breakover voltage ranges from 50 to 400 volts and an average rectified forward current of 3 amperes at 75°C and *1 ampere at 125°C stud temperature*. Maximum operating temperature is 150°C!

You are assured of uniform reliability through *completely diffused silicon construction* which provides higher power dissipation and high sensitivity.

Contact your local TI representative for immediate delivery of TI P-N-P-N controlled rectifiers in production quantities!

Write *for data folder containing complete parameters on Types TI 130, 131, 132, 133, 134 Diffused Silicon P-N-P-N Controlled Rectifiers.*



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These gearheads are designed to mount on the front of standard Bu-Ord, SAE. and RAE. size 11 motors, and can accommodate the different shaft lengths of these types. They have the same overall diameter and mounting arrangements as the motors to enable them to be mounted in a similar manner. Types are available modified for use with size 08 or size 10 motors, or on their own as speed reducers. In the design particular attention has been paid to robust construction and long life, ball bearings are used throughout and the materials and dimensions of the gears have been chosen to give minimum amount of wear.

PERFORMANCE SPECIFICATION

INPUT. The input gear meshes with the 13 tooth 120 DP. pinion of either standard Mark 14 motors, size 11 motors to SAE. ARP. 497 or size 11 motors to RAE. EL. 1789.

OUTPUT. The standard output shaft is splined 21 teeth 120 DP. with thread for shaft nut and drive washer. Alternatively plain shafts up to $\frac{1}{16}$" diameter may be supplied or a 13 tooth 120 DP. shaft suitable for cascading 2 or more gearheads, see shaft details below.

Maximum power output, torque not to exceed 80 oz in	$\frac{1}{2}$ watt
Maximum backlash after 500 hrs running with $\frac{1}{2}$ watt load	45 minutes measured on output shaft by reversing 8 oz in torque
Starting torque	0.2 gm cm
nertia at motor shaft	0.02 g cm^2
Operating temperature range	—54°C to +100°C
Tropical exposure test DTD 1085B	Withstood 28 days

RATIOS A number of ratios up to 600:1 are available as standard and these will probably satisfy most requirements:—Type G11A, 600:1; G11B, 300:1; G11C, 150:1, G11D, 60:1; G11E, 24:1; G11F, 80:1; G11G, 40:1 Other ratios can be provided.

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. . . airless space will limit performance of sensors . . .

vapor absorption, the sensors would see the top of the water vapor so that it could measure the tropopause or upper limit of the troposphere.

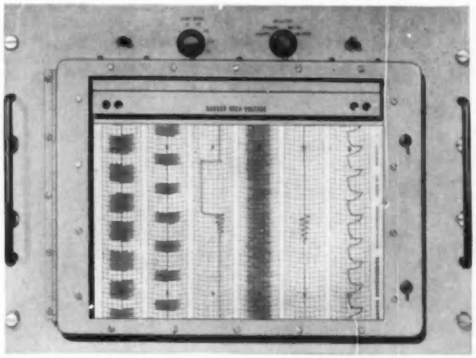
An attempt to do this will be incorporated in the Tiros satellite now under development, the speakers said. Tiros will carry instrumentation to scan the earth in five spectral regions: 1) 99 percent of the total incident solar radiation will be measured in the 0.2- to 5.0-micron channel; 2) black body temperature will be gaged in the 8- to 12-micron region; 3) water vapor absorption will be indicated by 5.6- to 7-micron radiation; 4) an image approximately the eye's response, will be obtained in the 0.55- to 0.75-micron range to help interpret the data obtained in other channels; and 5) a radiometer will use space as a cold reference.

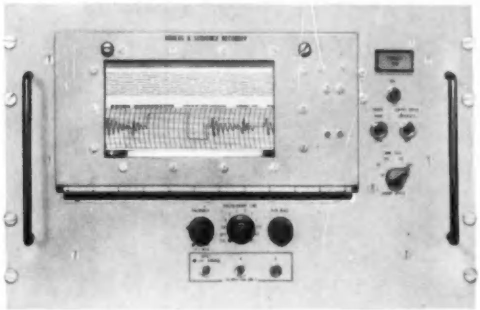
One of the five channels is described in the figure on p. 30. A half-mirror half-absorbing surface disk chopper will alternately switch the scan and reference beams to a thermistor bolometer detector. Amplified output will be stored on magnetic tape and telemetered to earth when the satellite passes over a readout station.

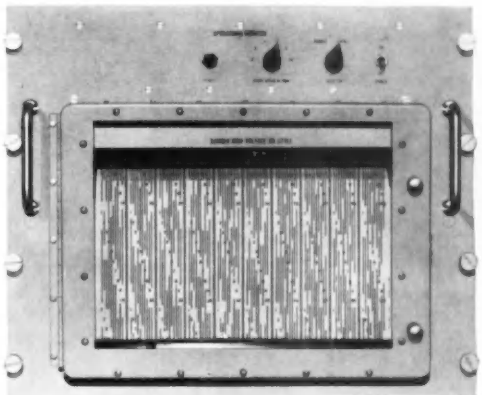
• **New phototape sensor**—Instead of using magnetic tape, E. C. Hutter, J. A. Insler, and T. H. Moore are using a new image-sensor tube which stores images on electrostatic tape. An image-orthicon electron gun provides read-in and read-out in the apparatus which has automatic winding and rewinding mechanisms.

Cloud information around the earth, the writers claimed, could be recorded in a continuous strip of pictures 100 ft long. The electrostatic tape can be read out several times before the charge image is destroyed; undeteriorated pictures have been read out after a two-week storage.

• **Effect of space**—Putting new sensors, like the ones described, into space may not be as easy as expected because of the environmental problems, two other RCA scientists, M. H. Mesner and M. Ritter, warned. Outside the earth's atmosphere, airless space will seriously limit both performance and life of sensors. Minutely low pressures at satellite altitudes, for example, will prevent the convection or conduction of heat between thermal sources and sinks. That means thermal transfer will be limited to radiative coupling and conduction through solids.







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Brush equipment is already at work putting evaluation data in writing for a whole new generation of weapons. When the weapons become operational, Brush MIL Recorders are a vital part of the system. This experience is unique in the industry. *Before* prototype design becomes a problem—call, write or wire Brush for complete details.

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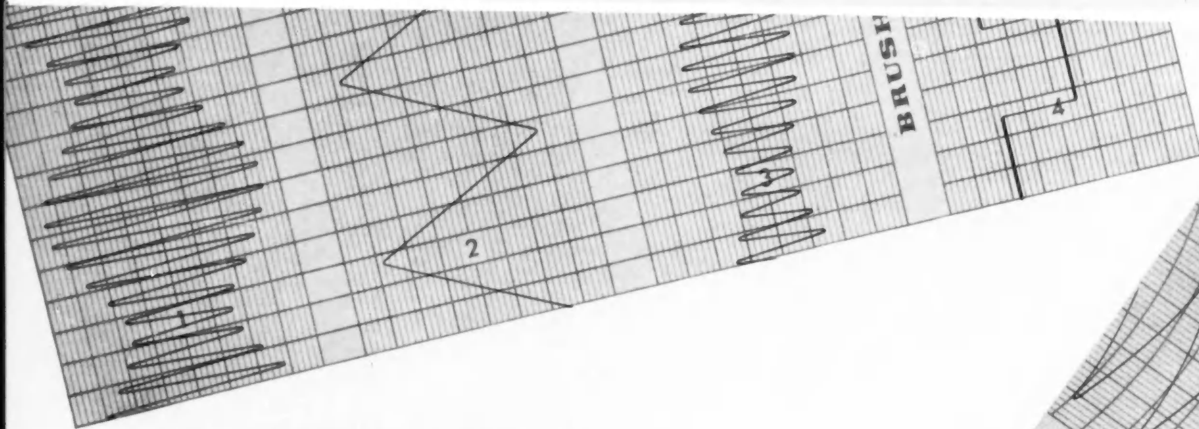

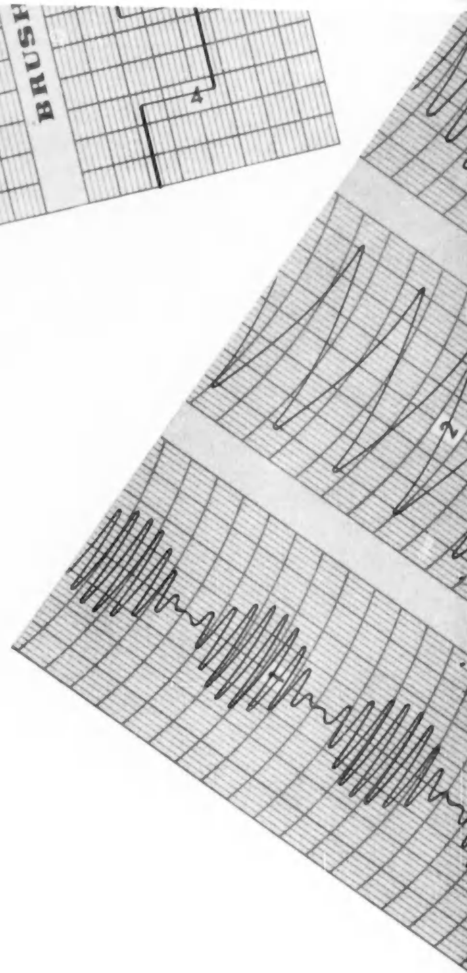

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East's Most Modern Pipeline . . .

starts operations, carrying 16 different products to 21 sales terminals and three connecting pipelines. It features automatic control with both digital and analog telemetry systems. And it is a case history on when not to use a computer for control.

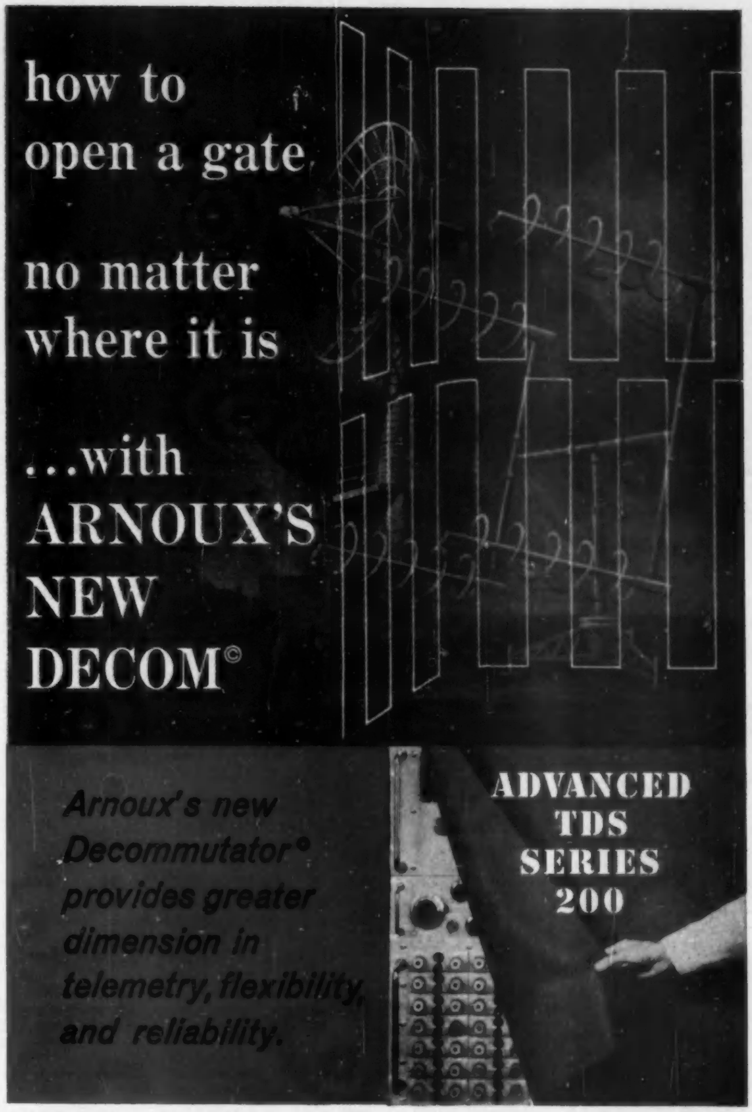
CAMP HILL, PA.—

Last month, The Laurel Pipe Line Co., jointly owned by Gulf Oil Co. (45 percent), Texaco, Inc. (30 percent), and Sinclair Refining Co. (25 percent), started operating over its full 447-mile length, carrying a variety of oil products from its eastern terminus in the Philadelphia-Camden area to its western end at Cleveland. Variety is Laurel's major problem: scheduling and keeping tabs on the 16 different oil products it will transport to 21 sales terminals and three pipeline connecting links. At its startup the system is moving 8,000 barrels per hr, can ship as high as 14,000 barrels per hr.

For scheduling, Laurel's dispatchers use a special hydraulic nomograph developed by the company's chief engineer, Marlan Jordan. Every 10 days, schedulers lay out a comprehensive plan, predicting where each product being transported will be in the pipeline every day. Applying the nomograph, the schedulers can calculate what pressure drops to expect, what pressure fluctuations deliveries will create, and the most economic pumping arrangement at each station (what combination of the three pumps at each station to use). The resulting schedule programs the operation of the system.

Tabs on the pipeline's performance are kept at Laurel's Camp Hill headquarters on a 52-foot panelboard that displays the input and discharge pressure and flows at each delivery point and pumping station. In addition, the board shows a measure of the capacitance of the fluid being pumped at each point, information used to identify the product. Flow measurements are converted to digital form close to where they are measured, then transmitted by microwave to Camp Hill. Flows, measured by positive displacement meters, are transmitted at accuracies of 0.03 percent. The ca-

←CIRCLE 34 ON READER SERVICE CARD



Arnoux's Decommutator© Series 200 continues to operate with one or even all information gates removed; active readout capability is from 1 to 88 channels, operating on all standard IRIG sampling rates of 30, 45, 60, or 90 channels at from 75 to 900 pps. All output patching and cross-strapping provided internally.

This new Decommutator uses a new gate-pulse generator, the DGG-1, which has a wide-range rate capability and can be adapted for *any* system requiring sequential gate pulses. Economy and smallness—the DGG-1 is only 3½ inches high and mounts in a standard rack. Selection of operating mode is by front-panel pushbuttons. A visual channel quantity counter is provided for proper system synchronization check. BULLETIN 801.

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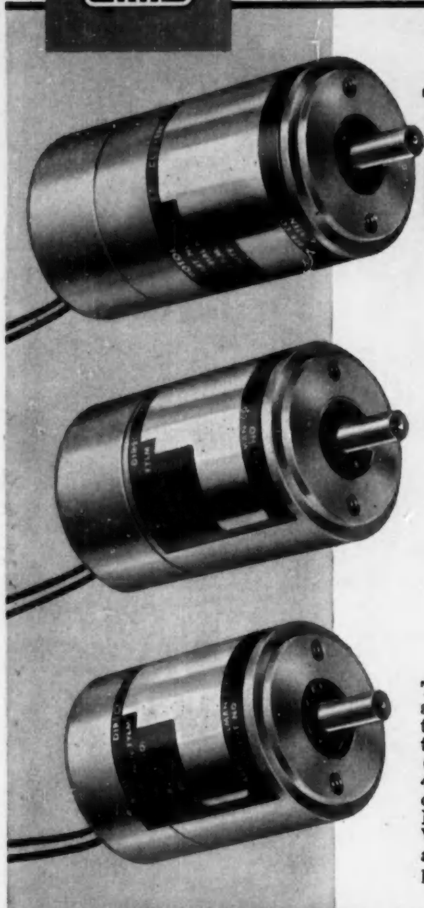
BARBER COLMAN

d-c small motors



TYPE FYLM

1¼" DIAMETER PERMANENT MAGNET MOTORS

- Three standard frame lengths
- Constant brush pressure over entire motor life
- Large, rugged bearings
- Very low ripple— 14-bar commutator and 14-coil armature
- Standard or special mountings for interchangeability with other motors
- Radio noise filters, gearheads and other special features available

This popular sized motor can be supplied in voltages from 6V d-c to 115V d-c. Normal ambient temperature range −65° to 200°F (can be designed for −100°F or 400°F). Rated output, 10 mhp continuous to 35 mhp intermittent. Rated torque, .05 lb-in. to .16 lb-in. Weight, .26 lb to .43 lb. If you have a new or replacement motor application, contact Barber-Colman.

THE WIDE LINE OF BARBER-COLMAN ELECTRICAL COMPONENTS includes: D-C Motors for industrial equipment and aircraft control applications. Output up to 1/10 hp . . . permanent magnet and split series types . . . various mountings and speeds . . . also available with gearheads or blowers. *Tach Generators* for accurate speed indication and servo rate control applications. *Low-cost battery-operated motors. Resonant Relays* characterized by low operating power, narrow band width. *Ultra-Sensitive Polarized Relays* operating on input powers as low as 40 micro-watts. *400 Cycle A-C Motors* for aircraft and missile applications.

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. . . oilmen see computers in longer, more complex lines . . .

pacitance measurement, from a Gulf-developed interface detector, is transmitted as an analog signal. General Electric supplied the digital telemetering and supervisory control.

• **Reasoning out a computer**—In the early planning of the Laurel system, chief engineer Jordan advocated the incorporation of a general-purpose digital computer for scheduling and performance comparison checks. (The computer could compare actual pumping performance with what had been scheduled, then send out control signals to bring the pumping rates up to the desired rate). But such an installation could not be justified economically, even though the system's information signals are already in digital form.

Mainly the computer would replace manpower; but at Laurel, remote control of pumping stations has already cut the labor force to such a small number that further savings could not pay for the computer. One of the four pumping stations, located at Duncansville, Pa., is remotely operated from Camp Hill; another station, at Mechanicsburg, Pa., has been designed for rapid conversion to automatic remote operation.

• **Where computers fit**—Will computing-control ever fit into pipeline control? Yes, say oilmen, in installations that are much longer and more complex than Laurel's 447 miles. Because the computer can't increase throughput very much, if at all, the computer will have to pay for itself almost completely from savings in manpower. Where that is possible, computers will control pipelines.

Navy To Buy Automatic Landing System

After eight years of development and three years of testing, the U.S. Navy will soon place production orders for an automatic landing system for carrier-based aircraft.

WASHINGTON—

The Navy Bureau of Ships will award the first contract for production of an operational-type system to land aircraft completely automatically. (AN/SPN-10) for use on aircraft carriers. The contract will presumably go to Bell Aircraft Corp., which has held

development contracts on the project since 1951.

First contract will cover production of three units. Navy plans are to buy at least seven more of the carrier automatic landing systems later. Cost of the first system to be delivered is estimated at $3-million—including tooling, manufacturer's drawings, and manuals. Eventually, the Navy believes the unit cost can be trimmed to about $500,000.

The system consists of a precise tracking radar, a comparative flight path computer, a data link, and the autopilot in a closed-loop system. The radar automatically tracks the approaching plane, supplying positional data to the computer. The actual flight path is then compared to a flight path objective. Correction signals are fed to the data link, which in turn transmits them to the plane's autopilot.

An experimental model of the AN/SPN-10 was installed aboard the carrier *Antietam* in 1957 and successfully tested (CtE, Oct. '57, p. 34). In a test, Navy fliers landed jet aircraft while clasping their hands together over their heads to dramatize the completely automatic feature. In all, the Navy has spent about $5-million on the project. In the initial stage Bell was in competition with Minneapolis-Honeywell. The Navy adopted "the best features" of each company's proposed system in 1954 and revised the specifications. Bell won the job of fabricating the experimental model.

Bell's prototype system included the Reeves "REAC" analog computer, but Bell will build its own analog machine for the operational system.

The aircraft company has modified the carrier automatic landing system for the Air Force and has delivered an experimental system for use in ground installations. Another version of the land-based model will be delivered in February to the Federal Aviation Agency at Atlantic City, N. J., for evaluation as a civilian tool.

The land-based version uses the basic principles of the carrier system but is less complex. The shipboard version requires a stabilizer to compensate for the pitch and roll of a vessel at sea.

The Navy considers the carrier automatic landing system a major element in modernizing naval air forces. The development of faster, high performance Naval planes had made the problem of landing on carriers much more difficult for the pilot. The AN/SPN-10 makes landing operations automatic, allowing precise approach and landing under all weather conditions.

—Morton Reichek
McGraw-Hill News

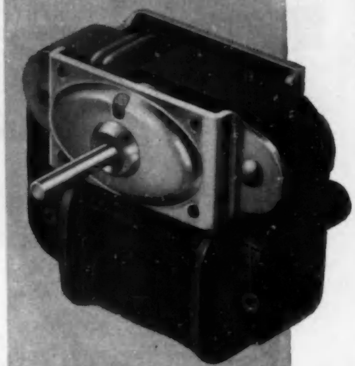
BARBER COLMAN

a-c small motors

high-torque unidirectional types

for quiet performance and long life

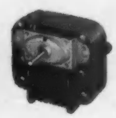
Outstanding for their high starting torque and low-inertia rotors, Barber-Colman motors are first choice for many of the nation's leading manufacturers. Low noise level . . . high dielectric strength coils . . . precision construction . . . compactness . . . long-life lubrication . . . and a quality guarantee backed by 30 years' experience are among the many other features of these motors that will assure long, trouble-free service in your product.



TYPE B

A high-quality motor at low cost that gives you a strong competitive advantage. Power output and starting torque exceptionally high in relation to size. Other "plus" features include alignable bearings . . . long-life lubrication . . . auxiliary oil cups . . . hardened and ground stainless steel shafts . . . ratings up to 1/200 hp.

TYPE A
Ideal for use in cramped quarters. Smallest unidirectional core-type motor in the line, yet has good starting torque and power output



TYPE F
Features extra high power to weight ratio while maintaining exceptionally good starting torque Porous bronze bearings, large oil wicks

TYPE R
High-torque Barber-Colman motor for heavier power requirements up to 1/20 hp. Heavy-duty construction for the most exacting applications.

Open and enclosed geared types

for longer life at lower cost

TYPE DZ

TYPE HZ

TYPE PZ

For longest life per dollar invested put Barber-Colman geared motors into your product. High-quality construction throughout . . . accurately hobbed gears, all of which are of properly heat-treated steel (except first step Textolite gear for quieter performance) . . . high torque, positive starting.

TYPE DZ — Open-type, double-gear plate motors for applications requiring a rugged, long-life motor. Designed to handle overhanging loads. Available in unidirectional, reversible, and synchronous models.

TYPE HZ — Low-cost, rugged, compact, high-torque motors available in unidirectional, reversible, and synchronous models.

TYPE PZ — Enclosed geared construction for mounting externally to driven device. Unidirectional, synchronous, and reversible models.

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Get the helpful condensed catalog of Barber-Colman shaded pole small motors. Contains complete descriptions of above motors, shows typical specifications, performance characteristics, control circuit diagrams. Write for your copy.

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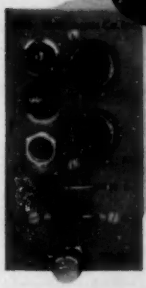
3 IN 1



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Fully transistorized, the power supply can be set for either voltage or current regulation by means of an internal switch. The span adjustment provides a choice of excitation voltages, continuously variable from 0 to 15 volts. The wide range balance control is suitable for use with virtually all transducers. There is a choice of four precision calibration resistors. Excitation voltage and gage signal voltage monitoring is provided.

Output	floating, 0 to 15v at 200 ma
Line Regulation	better than 0.1%
Load Regulation	better than 0.1%
Ripple	less than 1 mv
Noise and Hum to Ground	less than 10 microvolts peak to peak when measured with a 350 ohm strain gage bridge
Leakage Resistance	at least 10,000 megohms
Price	$145 plus calibration resistors, fob Santa Monica, Calif.

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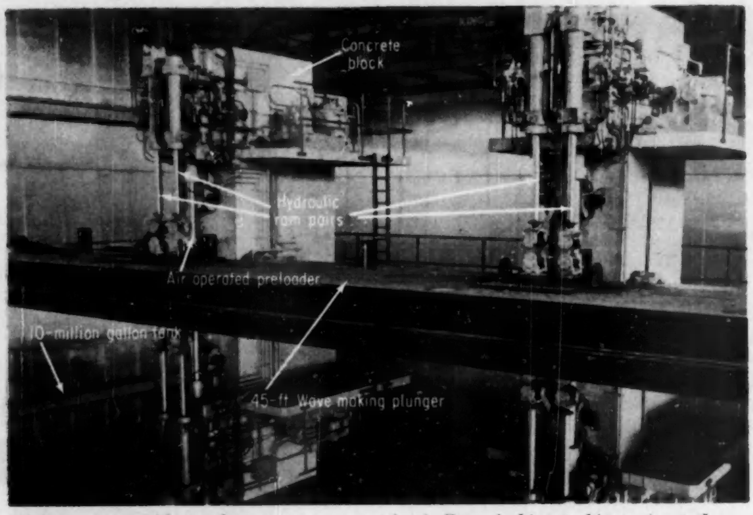


Miniature ocean with two large concrete mountains is Europe's biggest ship towing tank.

Electrohydraulic Wavemaker Simulates Angry Seas in Europe's Biggest Towing Tank

Miniature stormy seas are putting 40-foot ship models through rigorous hydrodynamic tests at Britain's National Physics Laboratory's new 10,000,000-gallon ship towing tank, the largest towing tank in Europe. Waves 40 ft wide and up to 2 ft high are generated by a unique electrohydraulically controlled wavemaker. Vertical oscillation of a 20-ton tapered steel plunger, which spans the 45-ft wide tank, generates the waves. Setting up programmed oscillations is the control system's main job.

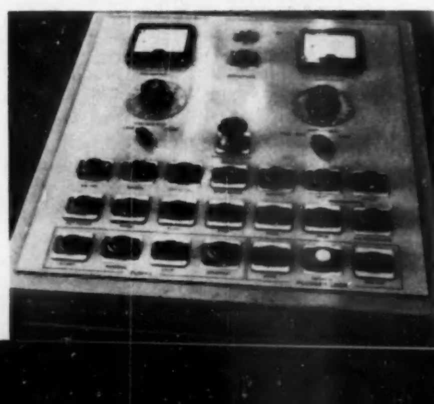
To transfer the tremendous power required for wave generation, the steel plunger wavemaker is driven by two pairs of hydraulic rams. For maximum stability the rams have been mounted on huge concrete blocks located at one end of the tank. Movement of the plunger can be varied in amplitude from zero to 1.5 ft, in period from 0.95 to 2.8 sec.

Designers of the control ran into three unexpected problems when actual fabrication started. First, the 20-ton plunger developed unlooked-for buoyancy, behaved like an air-filled tank. Water ballast in the plunger, a first answer to the problem, proved unsatisfactory because it added excess mass and inertia to the system. Finally designers decided to preload the plunger with an inertialess 20-ton thrust supplied by two air cylinders.

A second problem was imposed by the strict limits of movement of the plunger. When it is running in rail-guides, the plunger's maximum tilt between ends is limited to 4 min of arc, and plunger position has to be accurate to $\frac{1}{8}$ in. to assure specified wave amplitude accuracies. The answer to such rigid requirements turned out to be five overall servo loops which regulate plunger motion, holding it between these tight limits.

Third problem was how to raise the system's natural frequency to 10 cps to insure stiff control action when the plunger oscillated at its top frequency of 1 cps. By simulating the system on an analog computer, designers saw three weaknesses that had to be corrected. They changed the designs so that the rams of each hydraulic pair operated in parallel, instead of in series at high frequencies. They minimized pipe runs and liquid content by using closed hydraulic systems. And they switched to a synthetic oil

Wavemaker's control console.



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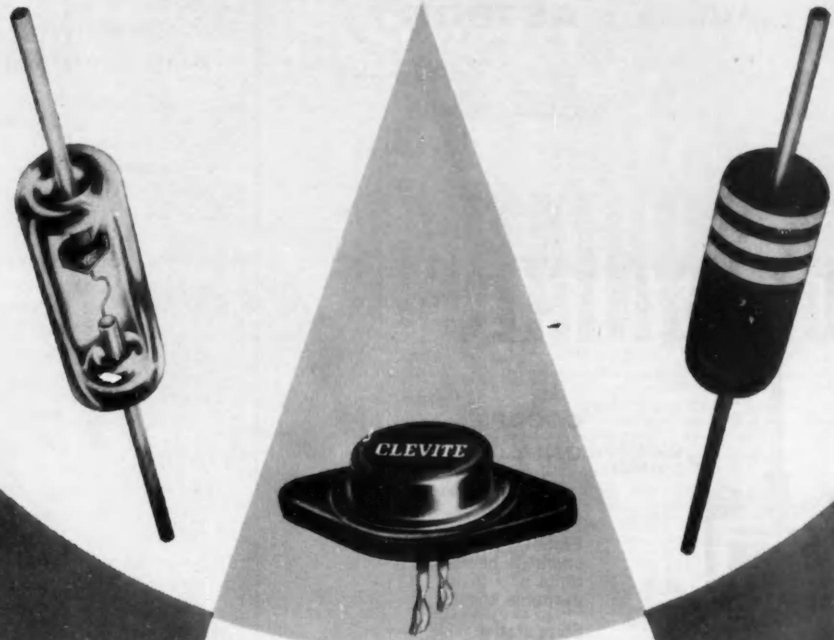

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Clevite diodes feature high forward conductance, fast pulse recovery, fast forward switching and extreme ruggedness to resist vibration and shock and to provide exceptional reliability

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- ***Fast Switching Types***
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Low thermal resistance, low saturation resistance plus superior current gain and high reliability construction make Clevite transistors your first choice for such applications as power converters, audio amplifiers, power supplies and high current switching circuits.

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- ***2 & 4 Watt Audio Types***
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NO. 2 OF A SERIES

THE SMALLEST **ASTRON**
SOLID TANTALUM
CAPACITOR

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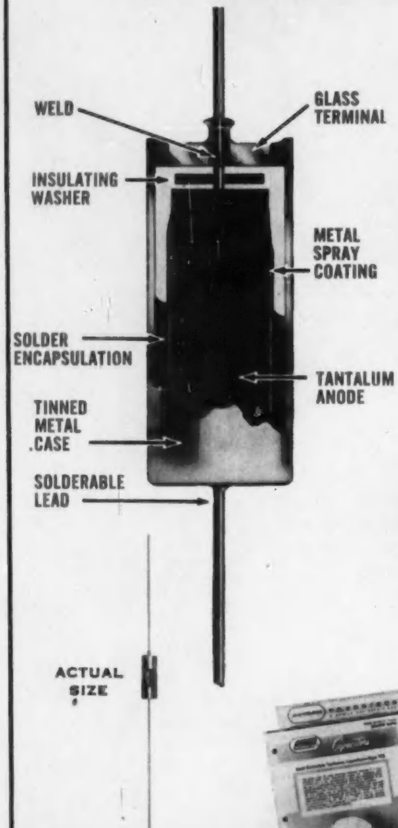

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Astron Tantalum Solid Electrolyte Capacitors are the smallest hermetically sealed units of a given rating available today.

Comparative sizes in cubic inches per microfarad-volt for various types of hermetically sealed and non-hermetically sealed capacitors are shown in the table.

CAPACITOR	RELATIVE CU. IN./MFD-V
Solid Tantalum	1.0
Wet Tantalum Slug**	.8
Etched Tantalum Foil**	4.5
Aluminum Electrolytic**	12
Metallized Mylar†	64
Metallized Paper	68
Paper*	130
Foil Mylar†	210

*INSERTED TAB
**MIL QUALITY, NOT HERMETICALLY SEALED
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FOR COMPLETE INFORMATION WRITE TODAY FOR BULLETIN E-675A AND FOR ASTRON'S DESIGN ENGINEER PUBLICATION, TECHNIQUES, VOL. 59, NO. 2

ASTRON CORPORATION
255 Grant Avenue
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SPECIALISTS IN CAPACITOR MINIATURIZATION

. . . servo valves on the main pump control the system . . .

with a maximum compressability of 0.4 percent, half that of normal mineral type oils.

• **Setting oscillations**—For short period oscillations, below 1.5 secs, the hydraulic cylinders operate with short, low velocity strokes. To raise the system's natural frequency under these conditions, all four hydraulic rams are operated in parallel. Oil flows through a closed circuit from the pump, via a combination valve, to one side of the hydraulic ram; exhaust oil returns to the main pump through a boost circuit.

At low frequencies, below 0.66 cps, additional hydraulic power is required for the higher velocity, long ram strokes. An automatic pilot-operated changeover valve supplies this extra power by connecting the two pumps in each main circuit in series. The additional flow feeds only one ram at each pair; the other ram is switched out of the circuit, opposing ports are opened so oil flows from one side of the piston head to the other.

• **Servo control**—Four two-stage electrohydraulic servovalves mounted on the main pump exert system control. At a console, inputs to the valves are generated in the form of a variable frequency and amplitude voltage. To obtain frequency control, a fractional horsepower motor drives a synchro transmitter through a precision reduction gear box. Output amplitude is set by a remotely controlled inductive potentiometer mounted in the main control cabinet below the tank.

Nonsinusoidal waves can be generated too. To do this, a cam follower is switched in to vary the control signal amplitude automatically. Shape of the cam has been derived from an analysis of magnetic tape recorded during full scale, rough, sea trials.

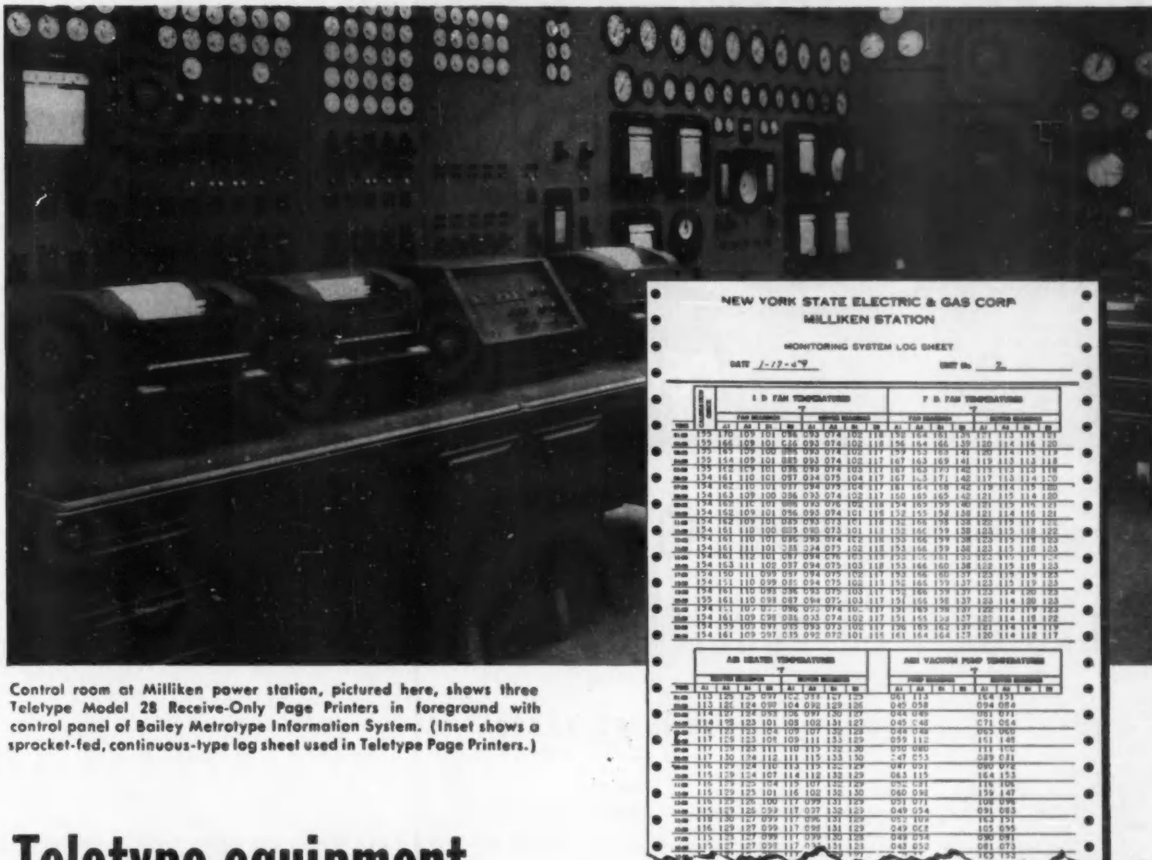
—Derek Barlow

British Engineer Salaries Poor Contrast to U. S. Earnings

LONDON—

Low salaries paid to engineers are forcing a technological emigration from the British Isles. Just how bad the salary situation is was shown last month when the British Central Office of Information made public the results of an engineer salary survey.

Automatic read-out . . .



Control room at Milliken power station, pictured here, shows three Teletype Model 28 Receive-Only Page Printers in foreground with control panel of Bailey Metrotype Information System. (Inset shows a sprocket-fed, continuous-type log sheet used in Teletype Page Printers.)

Teletype equipment monitors and records power station performance

New Model 28 Teletype Page Printers and Tape Punch equipment provide a continuous, dependable data processing facility for evaluating power station performance. This Teletype communication equipment is part of a Bailey Meter Company Metrotype® Information System installed recently at the Milliken power station of the New York State Electric & Gas Corporation, near Ithaca, New York.

This installation consists of two data systems:

1. A Monitoring System that continuously scans a total of 282 variables—temperatures of fan, motor and pump bearings; pressures of water and oil pumps, etc. Whenever readings exceed prescribed limits, system immediately reads and prints complete digital data of off-normal operation. In addition, complete readings are printed hourly.

2. A Performance System that scans 66 points once every hour, measures generator output, main steam flow, feedwater flow, temperatures, etc. All factors required to evaluate the station's performance are logged on the Teletype Printers. A Teletype Tape Punch also produces a perforated tape for IDP.

Robert Darke, Systems Division Manager, Bailey Meter, says, "Teletype equipment was chosen for this installation because of its flexibility and proven reliability. Design is simple and trouble-free, and the units are manufactured specifically for round-the-clock rather than intermittent service."

Teletype equipment will handle data for virtually any purpose in any industry. Signals may be serial or multi-wire. Signal medium may be local electrical circuit, telegraph or telephone circuit, or radio.

Why not find out how Teletype equipment can fit into your systems plan? Please write: Teletype Corporation, Dept. 22-M, 4100 Fullerton Ave., Chicago 39, Illinois.

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CIRCLE 41 ON READER SERVICE CARD

missilemen USE WIANCKO'S A1500 GAS-DAMPED ACCELEROMETER

ideal for aircraft and missile guidance

Wiancko's new gas-damped accelerometer employs a unique gas-damped seismic system which ensures a highly stable, accurate and reliable performance in severe environments. It provides continuous resolution, and is available in various ranges. Isolation transformers and associated circuitry can be supplied to provide proper phase relationships and temperature compensation for use as interchangeable units in control applications.

Compare these specifications

Damping	0.65 critical at 75° F
Damping variation with temperature	Change of less than 0.15 critical for a temperature change of 100 degrees F
Ranges	±1.0 g to ±25 g (unbalanced ranges available)
Linearity	1.0% of acceleration span or less
Hysteresis	0.1% of acceleration span or less
Temp. Range	−25° F to +180° F
Sensitivity Drift	Less than 2% of acceleration for a temperature change of 100° F
Weight	9½ ounces

If you want further information, write for product bulletin 112.

WIANCKO
ENGINEERING COMPANY

255 North Halstead Avenue • Pasadena, California

... since 1956 paychecks have not improved; most gains are in fringe benefits ...

Studying the annual 1955-56 paychecks of 6,000 members of the Institutions of Mechanical, Civil, and Electrical Engineers, the government agency reported that over 50 percent of the membership earned less than \$3,360, 30 percent earned \$2,800 or less. Only one engineer in four was paid higher than \$4,480 per year.

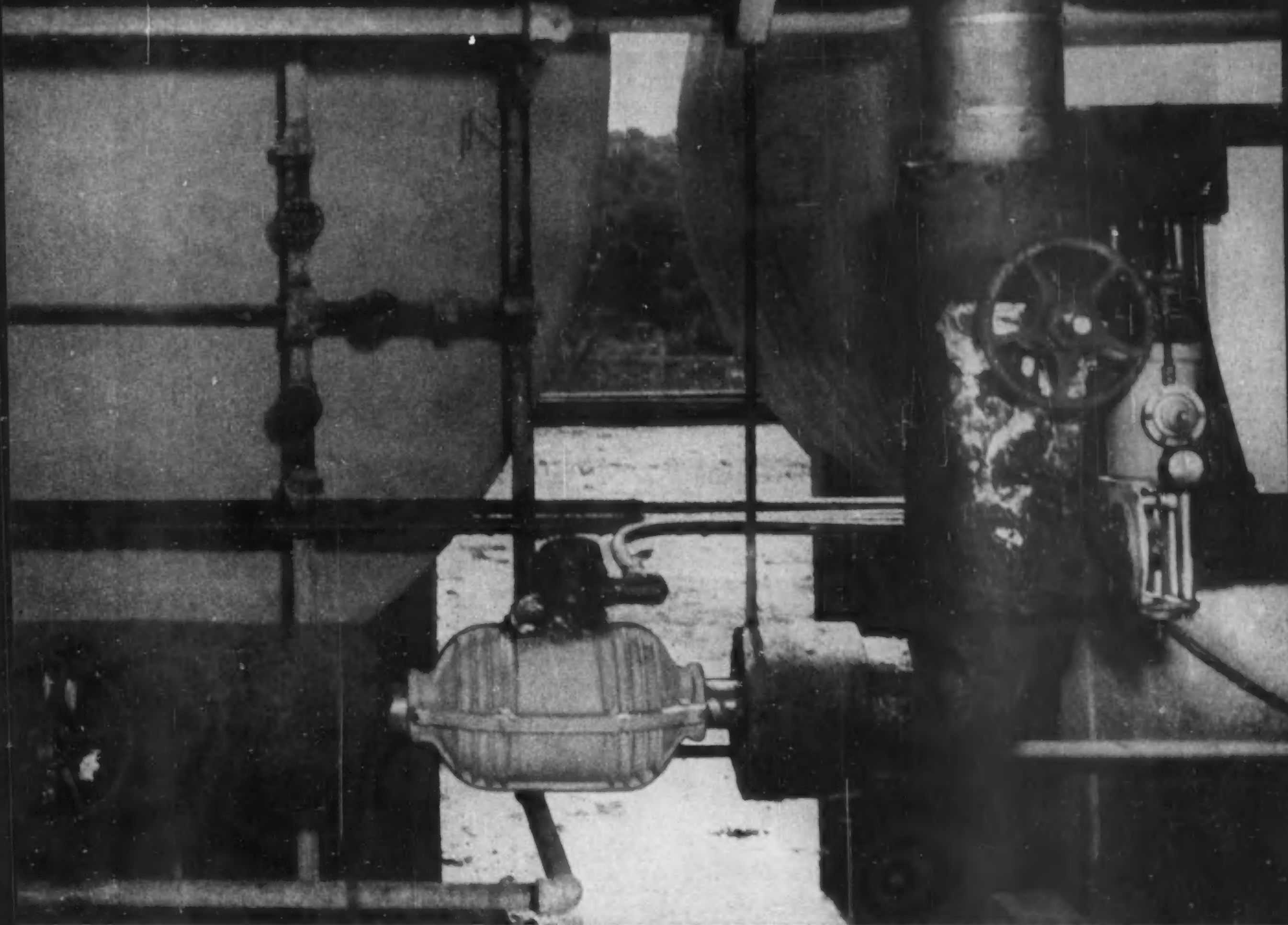
Since 1956 the pay of British engineers, and British control engineers in particular, has improved little. Salaries have increased about 10 percent. But real improvements have been mainly in fringe benefits such as free life insurance, contributory pension plans, housing help, and the use of company cars.

Checking present salaries in the chemical, petroleum, instrument and aircraft industries, CONTROL ENGINEERING learned that an engineer right out of school might expect to earn only \$2,240 per year. Promotion to a section leader, usually when an engineer is in his thirties, will raise his earnings to \$4,200 per year; top jobs as project managers earn around \$5,400 to \$5,600 per year.

British control engineers have even a more severe problem than salary: lack of recognition. "It is a change of heart, not a salary hike, that British control engineers are seeking. If we get the first, the second will follow," a top control engineer in a petroleum company said. The real problem, say British engineers, is the lack of top management enthusiasm for control systems. As a result of this apathy, a large number of British control engineers have left England for Canada and the United States where earnings are higher and management more receptive to new control ideas.

Russia Buys British Process Computer

The Soviet government has ordered a National-Elliot 802 medium speed transistorized computer from Elliot Brothers Ltd., of London. Although the Russians have not announced what they will do with the computer, it is reported that the machine will be used in the control of a power plant. Cost of the unit is \$60,000.



One of six Foxboro Magnetic Meters at International Salt Company's Avery Island Refinery. Meters are measuring 220°F sodium chloride brine being discharged from filters of International's Recrystallizer Process.

Foxboro Magnetic Flow Meters handle 220°F salt brine just like water!

"trouble-free" - International Salt reports

Foxboro Dynalog Instrument indicates flow rate through any one of the 6 Magnetic Meters — at the flip of a switch.

220°F — that's the temperature of sodium chloride brine as it leaves filters at International Salt Company's Avery Island Refinery in Louisiana. And their 6 Foxboro Magnetic Meters have been providing continuous, trouble-free flow measurement of this highly corrosive liquid for over a year.

These meters easily handle this punishing chemical. They're lined with corrosion-proof Kel-F — have no flow restrictions of any type. Linear measurement — accurate to ±1% across the entire scale — is indicated on remote Foxboro Dynalog* instruments.

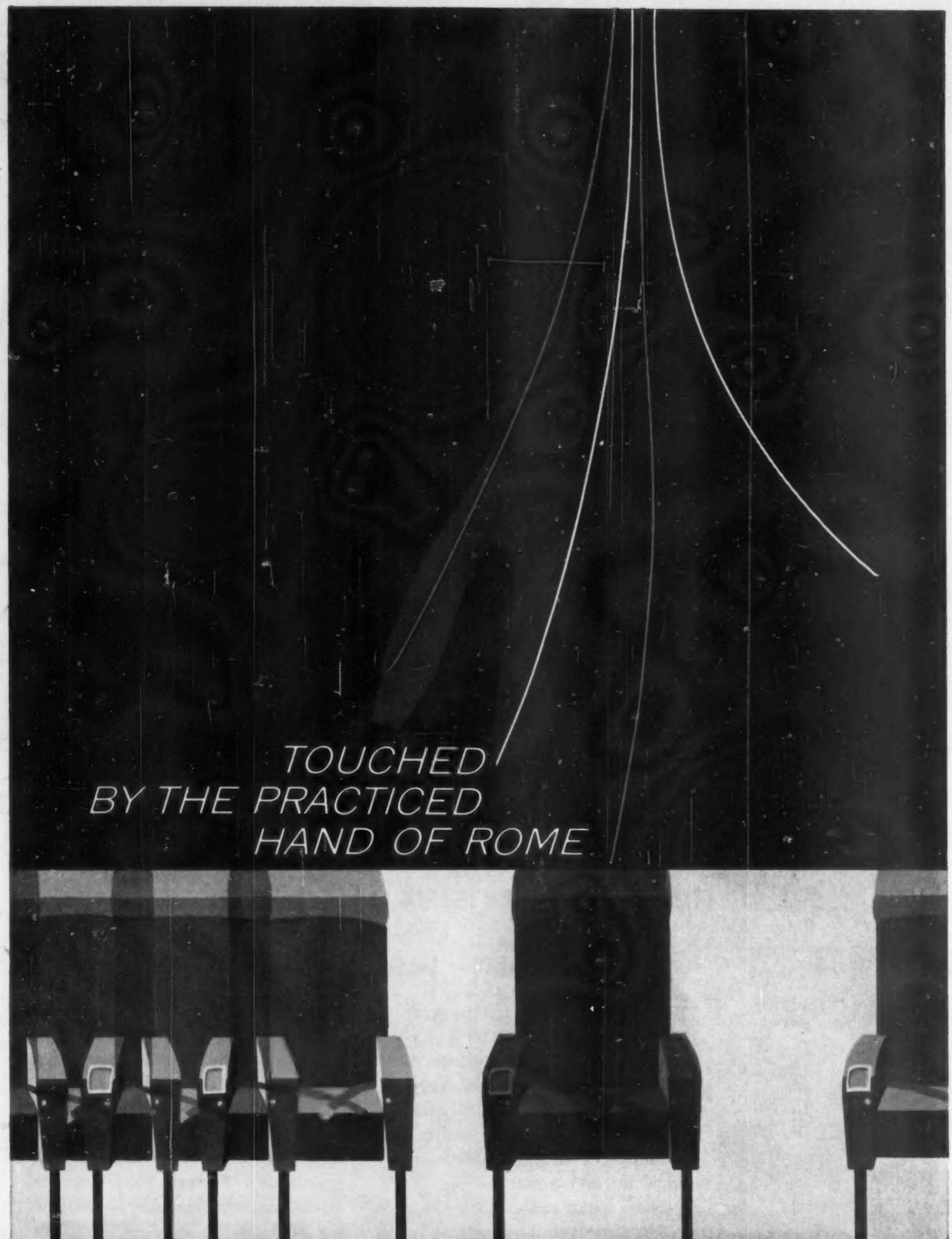
Since its introduction 5 years ago, the Foxboro Magnetic Meter has simplified the measurement of difficult liquids in hundreds of industrial processes. Ask your nearby Foxboro Field Engineer how it can help your process. Or write for Bulletin 20-14. The Foxboro Company, 3612 Norfolk Street, Foxboro, Massachusetts.

*Reg. U. S. Pat. Off.

FOXBORO

REG. U.S. PAT. OFF.

CIRCLE 43 ON READER SERVICE CARD



Univac Reservations Control Center for Eastern Air Lines provides fast service in confirming reservations between agents. Installation uses Rome control cable exclusively.

How to pick one seat in a million—reliably!

This remarkable Univac equipment locates one seat in a million in seconds to confirm reservations at Eastern Air Lines' new electronic reservation center in New York City.

Failure of any single component would seriously impair the effectiveness of the entire system. That is why all of its complex control-panel connections are made with Rome control cable—insulated and jacketed with Rome Synthinol (PVC) thermoplastic compound for high resistance to oils, acids, alkalies, grease, gasoline and flame.

The Univac links 135 Eastern Air Lines reservations and ticket agents in the New York area, as well as other agents in stations from Boston to Washington. It can store data on one million airplane seats up to one year in advance.

Though constructed with 75 conductors, this specially designed Rome control cable is slim and trim for quick and easy connections even in "tight" spots. Its rugged construction makes it ideal where maximum reliability is necessary.

Rome can help you solve control-panel problems on your job, too. If you need a special cable, as Eastern Air Lines did, Rome's engineers will design and build whatever your equipment requires. If standard cable is adequate for the job, Rome has a wide and complete line for you to choose from. Get in touch the next time you need help: Rome Cable, Dept. 1011, Rome, New York.

ROME CABLE
DIVISION OF **ALCOA**

CIRCLE 45 ON READER SERVICE CARD

Capital Spending Plans Head Higher in '60

Expenditures for plants and equipment are estimated to rise 10 percent next year, buttressed by spending that has been delayed by the steel strike. It means good business for instrument and control makers.

U. S. companies expect to spend \$37.3 billion for new plants and equipment in 1960—an increase of 10 percent over 1959. Manufacturing companies expect to boost their capital expenditures 19 percent to a total of \$12 billion. This optimistic note for instrument and control makers, whose sales are closely tied to capital spending, comes from this year's autumn McGraw-Hill Survey of Business Plans for New Plants and Equipment. The table indicates spending plans of specific industries, based on a wide sample of each industry.

Next year's spending should be helped somewhat by plans deferred by the steel strike. Actual capital expenditures for 1959 dropped significantly below spending plans indicated in the McGraw-Hill survey last spring, particularly in those industries directly hit by the strike (steel and railroads) and in the similarly strike-ridden nonferrous metals industry. Many other firms were unable to spend all they had planned because of steel shortages. The large steel and copper companies have been unable to enter their plants to carry out capital improvements; railroads have suffered such traffic losses that their ability to finance new equipment has been impaired.

• **Preliminary planning**—But the steel situation puts an added note of the unknown into this year's estimates. The survey represents preliminary planning—at the start of the budget season. Because of steel shortages and uncertain construction schedules, spending plans are even more tentative than usual.

The survey shows that some '59 expenditures will be carried over into next year. And 1961 plans are already at such a level that they may eventually equal or surpass those for 1960. One effect of the steel strike appears to be a stretching out of the spending over a longer period.

• **Steel to splurge**—The steel industry intends to make up for lost time in 1960 by raising expenditures sharply—**plans now indicate expenditures of \$1.7 billion or a 76 percent gain.** This is just \$174 million off

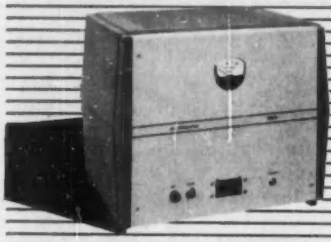
BUSINESSES' CAPITAL SPENDING PLANS

INDUSTRY	1958 Actual*	(Millions of Dollars) 1959 Estimated	1960 Planned	1961 Planned	1959–60 Percent Change
Iron & Steel	\$1,217	\$949	\$1,670	\$1,169	+76%
Nonferrous Metals	510	347	357	350	+ 3
Machinery	915	951	1,161	1,129	+22
Electrical Machinery	459	477	582	559	+22
Autos, Trucks, & Parts	558	647	841	791	+30
Transportation Equipment (aircraft, ships, RR eqpt.)	370	363	399	359	+10
Other Metalworking	723	880	875	844	− 1
Chemicals	1,320	1,188	1,473	1,502	+24
Paper & Pulp	578	613	828	704	+35
Rubber	134	178	233	247	+31
Stone, Clay & Glass	399	542	603	594	+11
Petroleum	4,819	5,220	5,154	5,077	− 1
Food & Beverages	742	794	783	737	− 1
Textiles	288	343	361	350	+ 5
Miscellaneous Manufacturing	883	1,061	1,037	1,022	− 2
ALL MANUFACTURING	9,761	10,025	11,957	11,171	+19
Electric & Gas Utilities	6,088	5,876	6,066	5,768	+ 3
ALL BUSINESS	32,091	33,914	37,310	34,566	+10

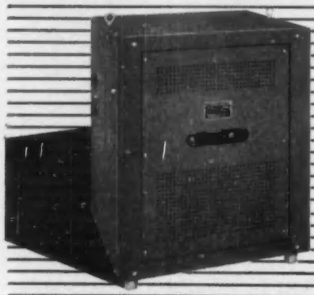
* *U. S. Department of Commerce, Securities and Exchange Commission, McGraw-Hill Dept. of Economics*

NEW IDEAS IN PACKAGED POWER

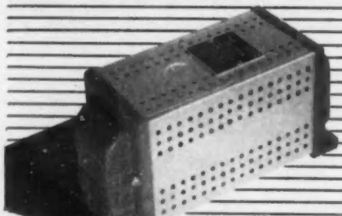
for lab, production test, test maintenance, or as a component or subsystem in your own products



New tubeless 0.1% a-c line regulators give up to 5kva out. High output and fast response result from a unique combination of semi-conductor and magnetic amplifier principles in the new Sorensen Model R3010 and R5010 a-c line regulators. Model R5010 (left) puts out up to 5kva and Model R3010, 3kva. Provision for remote sensing allows you to hold regulation accuracy at the load despite length of output leads, and, with an external transformer, permits regulation of any a-c voltage.



Broadest line of a-c regulators. A complete line of electronic a-c regulating equipment, supplying powers as high as 15kva, is manufactured by Sorensen. Single phase and 3 phase, 50, 60, 400 cps, 115 and 230 vac models are available. Good example of these is the 10kva Model 10000S supply (left). Others: Precision a-c regulators (±0.01%) for labs or meter calibration; and fast-response low-distortion a-c regulators where line transients must be reduced to a minimum.



... and rugged, economical MVR's. Low cost, low distortion, long life and a broad selection of models are outstanding features of Sorensen MVR's (Magnetic Voltage Regulators). Capacities range from 30 to 2000 va. Regulation is on the order of ±0.5%. Both harmonic-filtered and unfiltered models are available with 115vac out. Models for 6.3 and 12.6 out, unfiltered, also available.

Sorensen makes a complete line of packaged power equipment—including regulated d-c supplies, inverters, converters and frequency changers. Despite the breadth of the standard Sorensen line, our engineers are always ready to discuss your specialized power requirements up to complete power systems for complex computers or other critical equipment. Write for complete data. 8.43

Sorensen

SORENSEN & COMPANY, INC.
Richards Avenue, South Norwalk, Connecticut

WIDEST LINE OF CONTROLLED-POWER EQUIPMENT FOR RESEARCH AND INDUSTRY

IN EUROPE, contact Sorensen-Ardag, Zurich, Switzerland. **IN WESTERN CANADA,** ARVA. **IN EASTERN CANADA,** Bayly Engineering, Ltd. **IN MEXICO,** Electro Labs, S. A., Mexico City.

the record spent by steelmen in 1957. Such modernization may be difficult in a year when the steel makers will be striving for capacity output, since replacements and additions on the production lines may require shutdown. But the figures reported in the survey give clear evidence of the steel companies' determination to carry out their programs as quickly as possible.

Plans in other manufacturing industries are more modest, although **both chemical firms and machinery makers intend to spend well over $1 billion on new facilities in both 1960 and 1961.** Chemical company spending should rise 24 percent from this year's $1.2 billion with another 2 percent the following year. Machine builders' spending should increase 22 percent in 1960 to $1.2 billion; about the same amount should come in 1961.

Electrical machinery companies; the auto, truck, and parts industry; the paper and pulp makers; and rubber manufacturing industries all plan gains of more than 20 percent in 1960 expenditures. In each of these groups, except rubber manufacturing, 1959 estimates are lower than forecast in last spring's McGraw-Hill survey—indicating that spending is being pushed forward into 1960 as a result of strikes or uncertainties. Only food processors, the other metalworking group (which includes fabricated metals and instruments), and the miscellaneous manufacturing group expect lower capital expenditures in 1960 than this year.

• **Drop in petroleum spending**—One pessimistic note is sounded by plans in the petroleum industry, which is still bothered by an excess supply condition. Petroleum companies plan to spent 1 percent less in 1960 than they did in 1959. Expenditures for production facilities will decline 4 percent, offset to some extent by a 9 percent increase in refining equipment outlays.

The other transportation and communications industries plan a 14 percent increase in next year's spending. Commercial companies report record plans for 1960—$8.6 billion compared with $7.9 billion in 1959 and $8.2 billion in 1965, the previous peak year. The electrical and gas utilities indicate they expect to spend $6.1 billion in 1960—up 3 percent from this year only slightly off the record of 1957.

• **Sales up 9 percent**—These plans for higher capital expenditures are supported by optimistic sales estimates—9 percent above 1959—for unit sales in all manufacturing. Steel companies expect a 25 percent sales increase. The group including instrument makers expects sales up 7 percent.

0110 1001 1001 1000

RECOMP

THINKS IN "BITS" BUT TALKS YOUR LANGUAGE

The binary combinations of ones and zeros stored in computers are called "bits"... and there are 160,000 of them stored in RECOMP.

RECOMP's exclusive readout panel converts these "bits" into arabic numerals... providing fast, easy readout of any word or number in the magnetic disk memory. RECOMP *communicates* in your language. Under computer control or at the push of a button, the unique readout displays in a choice of three formats: decimal, octal, or command.

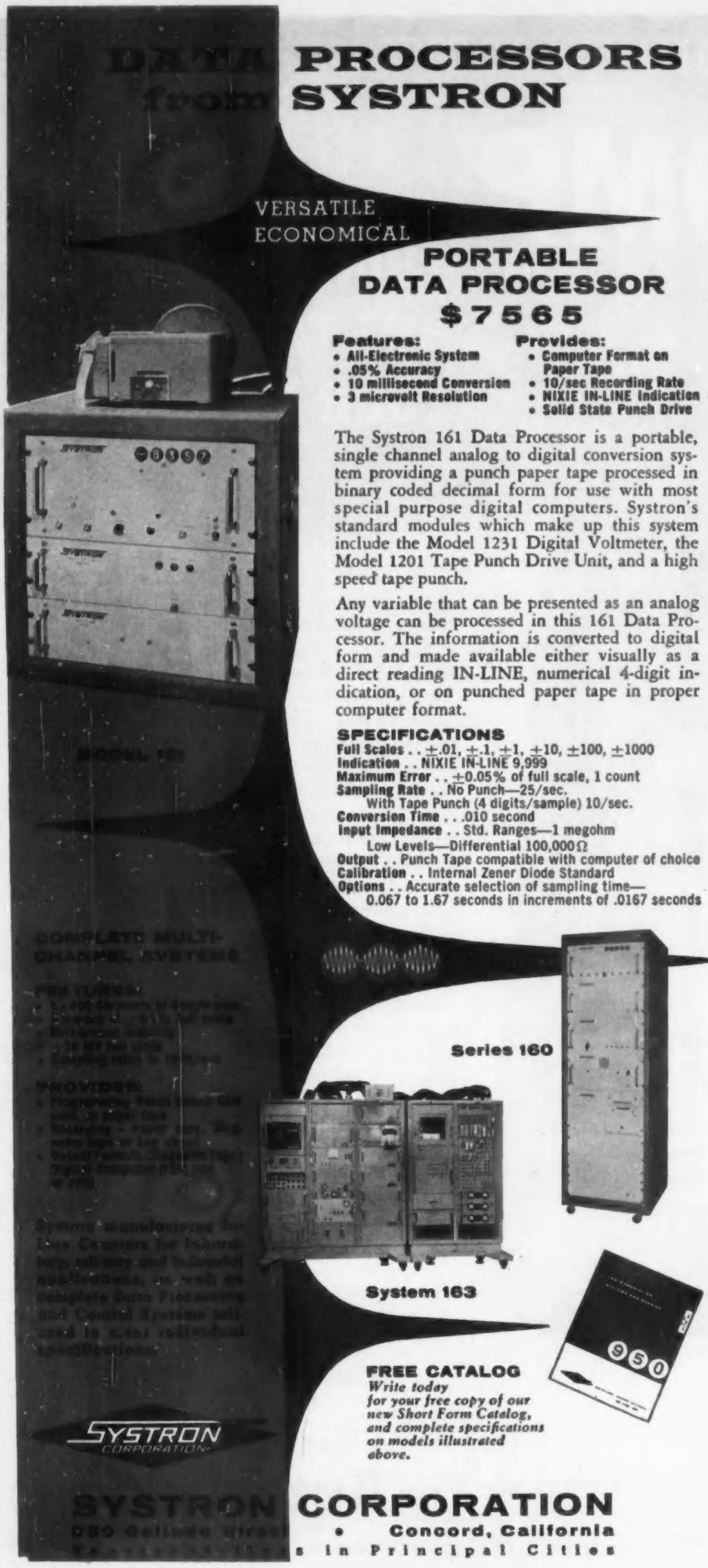
The all-transistorized, general purpose RECOMP has built-in floating point and square root arithmetic... high-speed photoelectric tape reader (400 characters per second)... 4,096-word memory, including 16 words placed in high-speed loops, and a storage capacity of over 8,000 instructions.

RECOMP provides fast and accurate answers to problems of engineering, science and industry. It's available now for sale or lease... *and there's no extra equipment to buy or cost of installation.* For information on how RECOMP can solve your special problems, please write Autonetics Industrial Products, Dept. 312, 3584 Wilshire Blvd., Los Angeles 5, California.

Digital computers by Autonetics

INDUSTRIAL PRODUCTS

A DIVISION OF NORTH AMERICAN AVIATION, INC. Other offices: Chicago, New York, Washington, D.C.



WHAT'S NEW

Daystrom's Asian Pact May Boom Instrument Imports

From Tokyo, Japan, and Newark, N. J., comes news of a reciprocal arrangement that may have far-reaching effects on the U. S. instruments and control industry. Daystrom's International Div. has signed a joint marketing agreement with Japanese trading company, Nichemen & Co. Ltd.

Daystrom and Nichemen have set up a new Japanese firm, Daystrom-Nichemen, KK, which Daystrom will control with 51 percent ownership. Daystrom will also hold three out of five seats on the board of directors. Purposes of the firm, to be based in Osaka: to provide Daystrom with outlets for its products in the far eastern markets, and more important, to buy Japanese electronic goods for resale in the U. S. Daystrom-Nichemen will also make arrangements with Japanese manufacturers to turn out equipment using Daystrom patents and knowhow.

Daystrom International's president, William H. Westphal, told CtE that "Japanese competence and complete instruments will be imported into the U.S.A. under both Japanese and Daystrom labels." One problem that Daystrom seems to have solved is the Japanese government's reluctance to allow profits to leave the country. Says Westphal, "Daystrom has sufficient faith in the future of Japanese currency not to insist on convertibility guarantees." But rumors in Tokyo hint that Daystrom will go around the restriction. The newly formed trading company, it is rumored, will ship equipment from Japan with only enough markup to cover Daystrom-Nichemen's costs—and then the profits will be added to the stateside price.

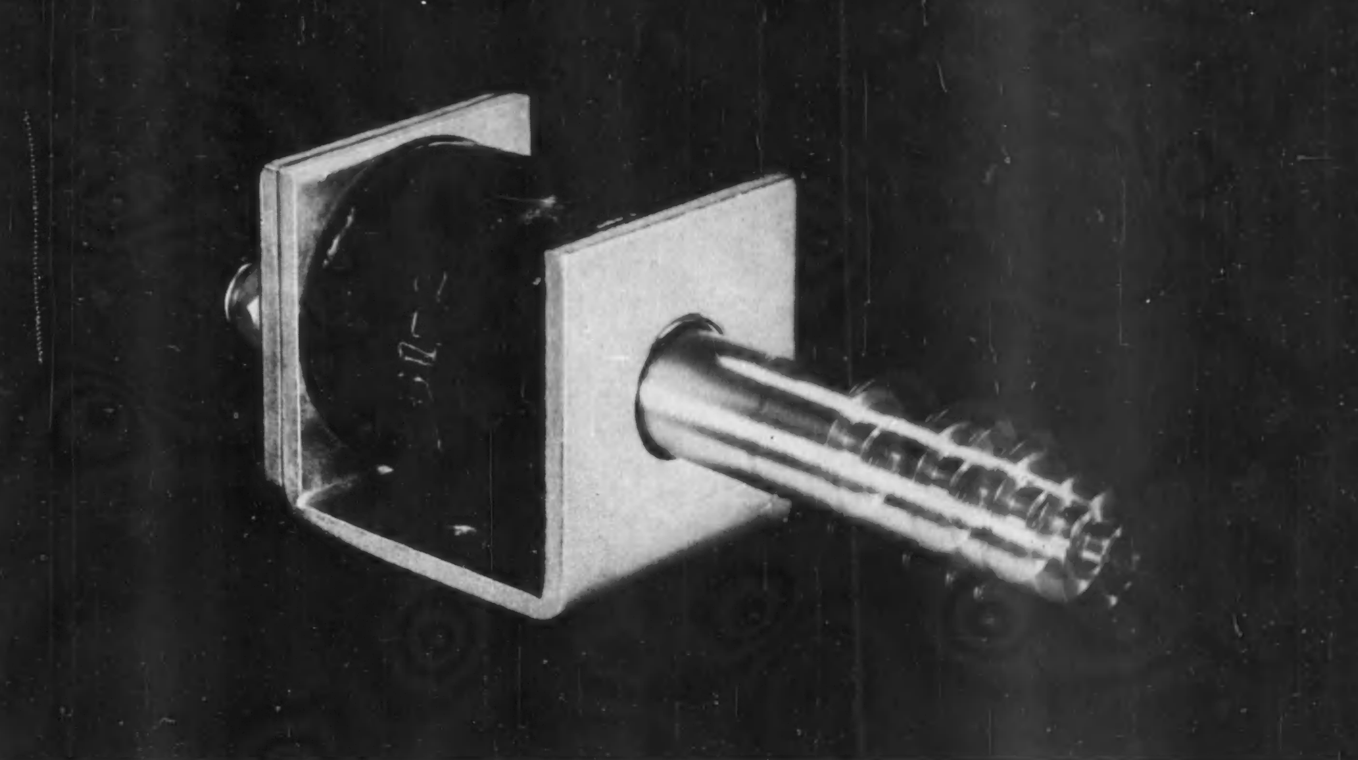
Most significant aspect of the agreement is that it may signal the start of an inrush of Japanese instruments and control equipment to the U. S.

CEC To Merge With Bell & Howell Co.

Consolidated Electrodynamics Corp., aircraft and missile equipment, instrumentation, and control systems builder, will merge early next year with Bell & Howell Co., photographic goods maker, if directors and stockholders approve. After the marriage, the two companies will continue to operate separately, with individual organizations and managements.

B & H comes into the merger in the strongest financial shape in its his-

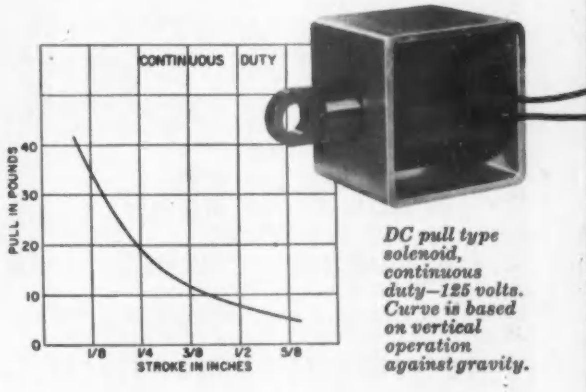
100 MILLION OPERATIONS!



new ASCO solenoid has virtually unlimited life!

This is ASCO's new long-life solenoid. Unlike ordinary solenoids where plunger rides loosely in the sleeve this device is precision manufactured to tolerances of ± .0005". A rugged machine tool bearing guides plunger to provide accurate, smooth stroking. There is virtually no wear—almost unlimited solenoid life.

If your application calls for a precision solenoid that must operate consistently and indefinitely, investigate this new long-life ASCO design. ASCO solenoids are available to meet a wide variety of applications. For additional information contact your ASCO engineer or write for Catalog 57-S5.



DC pull type solenoid, continuous duty—125 volts. Curve is based on vertical operation against gravity.

ASCO Electromagnetic Control

Automatic Switch Co. 50-G HANOVER RD., FLORHAM PARK, N. J., FRONTIER 7-4600

AUTOMATIC TRANSFER SWITCHES • SOLENOID VALVES • ELECTROMAGNETIC CONTROL

ASCO

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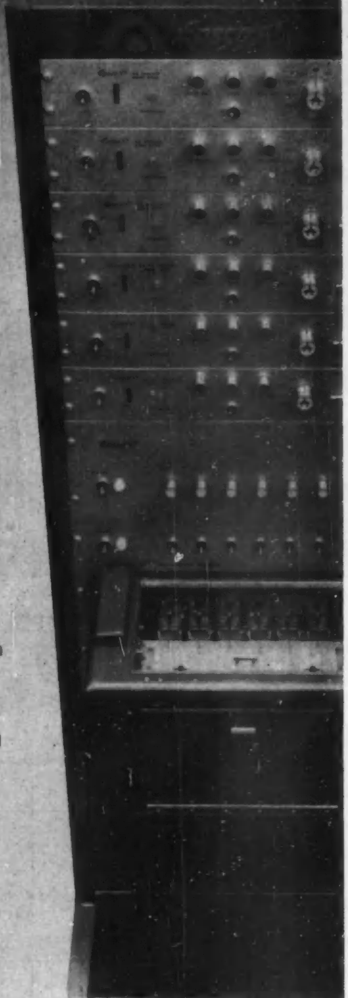
VIEWED FROM ANY ANGLE



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In production testing, research and development engineering for all industry where Versatility, Performance and Economy are essential.

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Interchangeable amplifiers will accommodate a wide range of transducers. Whatever the level or character of the signal, there is an EPSCO preamplifier to handle it.

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Sensitivity — from 10uv per mm and Strain measurement as low as 1 micro-inch per inch per mm.
Frequency Response — from D.C. to 200 cps produced through Plug-in compensators which provide extended frequency response or sharp cut-off.
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ECONOMY

- Low initial cost. Model 8205-6 (illustrated) 6 channel ink writing system complete $4,365.00
- Low operating cost. Compared to other writing systems, EPSCO's operating costs average up to 5 times less.

NO ADDITIONAL EQUIPMENT OR ACCESSORIES ARE NEEDED TO MAKE THIS DYNAMIC RECORDING SYSTEM COMPLETE.

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INSTRUMENTATION FOR INDUSTRY AND MEDICINE

Epsco WORCESTER
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tory: 1958 sales were $59 million, first nine months' earnings this year were highest ever with a traditionally peak quarter still to come. CEC, on the other hand, has just started to move into the black after a poor fiscal 1958.

The disappointing year left the Pasadena, Calif., firm short on working capital. Its products, aviation and missile test equipment, instrumentation and control systems, magnetic tape equipment, and vacuum systems and controls, are largely proprietary; and the company requires abundant capital to stay competitive. B & H, whose profits are geared to population growth and the booming U.S. standard of living, can provide substantial financial backup.

In addition to motion picture and photographic equipment, the Chicago firm makes optical goods, audiovisual devices, and microfilm gear; the company has also entered the office equipment field with inserting and mailing machines.

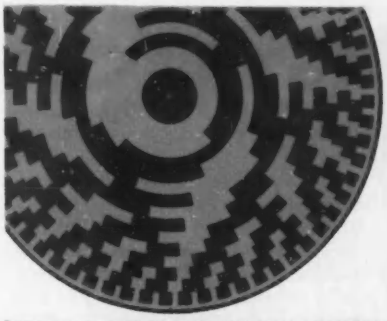
The merger will not be one-sided. The product lines of both companies dovetail neatly. B & H expects considerable help from CEC applying electronic techniques to its photographic and office equipment. CEC, in return, plans to apply B & H's photographic experience to the instrumentation and control fields.

Negotiations Underway To End F-108 Control Contracts

After cancelling the F-108 Mach 3, long range interceptor-fighter in September, the Air Force is now terminating contracts on this project on which it has already spent $150 million. Major recipient of USAF's attentions is North American Aviation, Inc., prime contractor for the defunct "Rapier". As weapon system manager, NAA must in turn negotiate termination agreements with its many subcontractors (70 percent of the project was to have been farmed out). Because of the nature of supersonic aircraft like the F-108, many of these contracts are for controls and instrumentation.

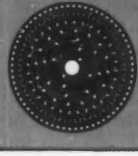
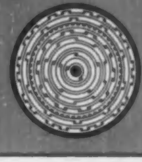
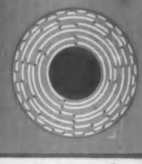
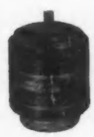
Most seriously affected are these control subsystem contractors: International Telephone and Telegraph Corp.'s Federal Div., Garrett Corp.'s AiResearch Div., Marquardt Aircraft Co., and United Aircraft Corp.'s Hamilton Standard Div. A fifth control subsystem, being built by Hughes Aircraft Co., is being continued.

• **Air data scrapped**—AiResearch was subcontractor for the F-108 central air data computing system which was to



How do you want your digital data?

Norden Converters offer varied outputs

	TYPICAL MODELS					
Converter Disc						
Code	Binary*	Binary	GRAY	Binary-* Decimal	Degree-* Counting Binary-Decimal	Latitude/* Longitude Binary-Decimal
Number of Models	9	3	4	7	6	2
Total Count Range	2^7 to 2^{19}	2^7 to 2^{19}	2^8 to 2^{16}	10^2 to 10^6	360 to 360,000	36,000
Available Counts per Turn	128, 256, 512, 1,024	128	256, 512, 1,024	100, 1,000	100, 360, 360,000	10
Diameter	1¾"	1¾"	1¾", 2¼", 3¼"	2¼", 6¼"	2¼", 3¼", 3⅜"	2¼"
						

* V-brush logic included within encoder.

Norden shaft position encoders translate analog input into a variety of digital outputs. The 31 standard Norden converters listed here are available for a wide range of applications and deliver digital data in several codes. Integrally mounted synchros are also available. Norden engineers welcome the opportunity to design special equipment to your specifications.

Norden encoders are known and specified for high accuracy and reliability. Small size, long life, and the capability of continuous performance under severe environmental condition are built-in characteristics assured by Norden's engineering ingenuity and precision production facilities. Write Norden, or call TRinity 4-6721, for complete data or engineering consultation.

NORDEN

NORDEN DIVISION

UNITED AIRCRAFT CORPORATION

Milford Department, Wiley Street, Milford, Connecticut

CIRCLE 51 ON READER SERVICE CARD

serve as a central pickup for important data like pressure, temperature, acceleration, and angle of attack. The information would have been processed and fed to the pilot and to other subsystems. More than half of the subsystem was to have been subcontracted. ITT Federal's mission and traffic control subsystem was to provide communications, navigation, identification, and landing aid functions.

Hamilton Standard's air conditioning and pressurization (environmental control) subsystem is also designed for NAA's B-70 bomber project, which is being continued. So the F-108 cancellation's impact on HSD is not as overwhelming as for the other contractors. The F-108's air induction control subsystem was to have been provided by Marquardt. Its purpose was to regulate the inlet air supply to the plane's two GE J-93 engines.

• **Fire control retained**—The fifth controls subsystem, fire control, has been under development by Hughes on a prime USAF contract that had been tied into the company's work on the GAR-9 missile, an advanced version of the Falcon air-to-air missile (but with nuclear capability and much greater range). The dual development program is being continued for "possible application to other weapon systems". About $70 million has already been committed on the fire control subsystem and the advanced air-to-air missile, making this one of the most costly phases of the F-108 program. The Air Force says that Hughes work will "go forward at a reduced level"; a new contract is now being negotiated with the company.

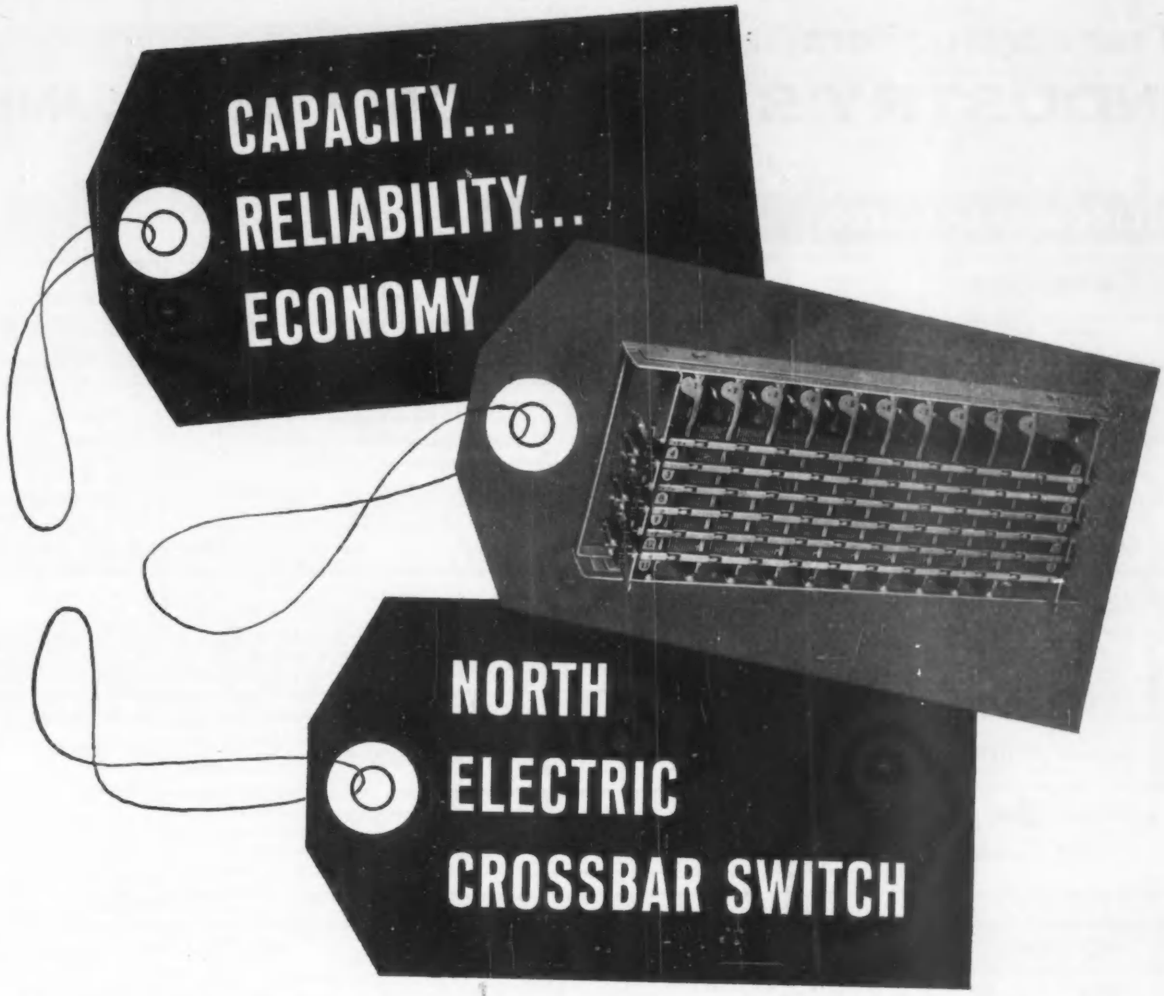
The $150 million total already spent on the project does not include another $50 million that had been committed at the time of cancellation.

TACO Tracks a New Market

When Technical Appliance Corp. (TACO) was founded by motorcycle-racing Carl Goudy in 1931, it was a tinkerer's company, one that would tackle the building of almost any kind of electrical or mechanical device. Doing this started the company in the home TV antenna business in 1938. But the company really didn't start to grow until the early fifties when the TV market exploded.

With its head start in the TV antenna business, TACO expanded rapidly, took advantage of the sudden insatiable demand for home units. The TV antenna boom slumped, un-

(Continued on page 165)



THE NORTH CROSSBAR SWITCH PROVIDES GREATER INDUSTRIAL SWITCHING CAPACITY IN LESS SPACE—WITH TELEPHONE RELAY RELIABILITY—AT LESS COST!

Designed and built on a matrix coordinate 10 x 12 configuration, with up to 10 circuits per crosspoint, providing sequential crosspoint selection for as many as 1200 switching points, the North Crossbar Switch is the most economical switchgear available to do so much in so little space! Measuring only 22.95 inches long, by 5.35 inches wide and 8.67 inches high, two Crossbar Switches will easily mount side by side vertically in a standard 19 inch frame!

The North Crossbar Switch is being used in analog and digital computer functions, as a memory device for programming and sequencing, for high traffic communications, machine tool control and programming, data storage and reduction, digital to analog conversion, automatic test programming, computer readout, cable and circuit testing, high capacity selector switching and a host of other industrial applications.

Featuring multi-path selection, double wound hold coils, ball bearing pivot pins, the North Crossbar Switch requires minimum maintenance with virtually no moving parts or mechanical wear. Both mechanical life and contact life are in excess of 50 million operations!

Select and hold magnet coils are available for operation on 24, 48 and 100 volts D.C.

FOR ADDITIONAL DATA ON THE NORTH CROSSBAR SWITCH—write:

INDUSTRIAL DIVISION

NORTH ELECTRIC COMPANY

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Transitron offers...

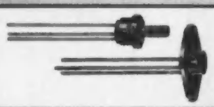
INDUSTRY'S MOST COMPLETE LINE

SILICON TRANSISTORS

JAN TRANSISTOR		Minimum Current Gain (B)	Maximum Collector Voltage (Volts)	Typical Cut-off Frequency (MC)	Maximum I_{co} @ 25°C and V_c Max. (μa)	FEATURES
	JAN-2N118	10	30	10	1	• Only Jan Silicon Transistor

SMALL SIGNAL		Minimum Current Gain (B)	Maximum Collector Voltage (Volts)	Typical Cut-off Frequency (MC)	Maximum I_{co} @ 25°C and V_c Max. (μa)	FEATURES
	2N333	18	45	7	50	• Low I_{co} • Operation to 175°C • 200 mw Power Dissipation
	2N335	37	45	10	50	
	2N480	40	45	11	.5	
	2N543	80	45	15	.5	
	ST905	36	30	10	10	

HIGH SPEED SWITCHING		Typical Cut-off Freq. (MC)	Maximum Collector Voltage (Volts)	Maximum Collection Saturation Resistance (ohms)	Max. Power Dissipation @ 100°C ambient (MW)	FEATURES
	2N1139	150	15	60	500	• High Frequency Operation • Low Saturation Resistance • Low I_{co}
	2N337	20	45	150	50	
	2N338	30	45	150	50	

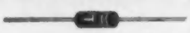


MEDIUM POWER		Max. Power Dissipation @ 25°C Case (Watts)	Maximum Collector Voltage (Volts)	Minimum DC Current Gain (B)	Typical Rise Time (μsec)	Typical Fall Time (μsec)	FEATURES
	2N545	5	60	15	.3	.5	• Fast Switching • High V_c • Rugged Construction
	2N547	5	60	20			
	2N498	4	100	12			
	2N551	5	60	20			
	2N1140	3	40	20	.2	.1	

HIGH POWER		Maximum Power Dissipation .. 25°C Case (Watts)	Minimum DC Current Gain (B)	Typical Collector Saturation Resistance (Ohms)	Maximum Collector Voltage (Volts)	FEATURES
	ST400	85	15 @ 2 Amps	1.5	60	• High Current Handling Ability • Low Saturation Resistance • Rugged Construction
	2N389	85	12 @ 1 Amp	3.5	60	
	2N424	85	12 @ 1 Amp	6.0	80	

Write for Bulletins: TE-1353 and TE-1355

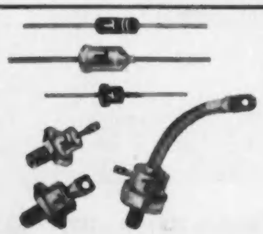
SILICON DIODES



	Fast Switching and High Frequency Types Ratings @ 25°C				Military and High Conductance Types Ratings @ 150°C			
FEATURES		Max. Inverse Voltage (Volts)	Max. Average Fwd. Current, (ma)	Inverse Recovery Time (μsec)		Max. Inverse Voltage (Volts)	Max. Average Fwd. Current (ma)	Max. Inverse Current (μa) @ V
• Recovery Times Under 15 μsec • High Conductance Combined With Fast Switching • Subminiature Size • High Inverse Resistance	1N808	100	100	.3	JAN 1N457	60	25	5 @ 60
	1N809	200	100	.3	JAN 1N458	125	25	5 @ 125
	1N658	120	200	.3	JAN 1N459	175	25	5 @ 175
	1N659	55	100	.3	1N485B	180	50	5 @ 175
	1N643	110	100	.3	1N488A	380	50	25 @ 380
	JAN 1N251	30	75	.15	1N464	175	40	30 @ 125

Write for Bulletin TE-1350

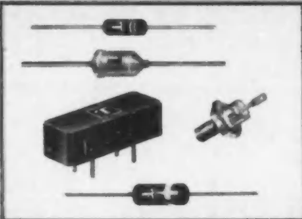
SILICON RECTIFIERS



Ratings @ 150°C Case Temperature			Peak Recurrent Inverse Voltage (Volts)	Maximum Average Forward Current (ma)	Maximum Inverse Current (ma)	FEATURES
	Subminiature Glass	1N689 1N649	600 600	150 150	0.2 0.2 (@ 25°C)	• Reliability at High Temperatures • High Efficiency • Rugged Construction • Hermetic Sealing • Low Thermal Resistance
	Miniature	TJ60A TJ30A	600 300	200 200	0.5 0.5	
	Axial Leads	SL715 1N547	1500 600	100 250	0.2 0.3	
	Military	JAN 1N256	570	200	0.25 (@ 135°C)	
	Stud Mounted	TM155 TM67	1500 600	400 3000	0.5 0.5	
	Medium Power	TR402 TR601	400 600	Amps 20 10	5 5	
	High Power	TH402B	400	50	15	

Write for Bulletin TE-1351

SILICON REGULATORS AND REFERENCES

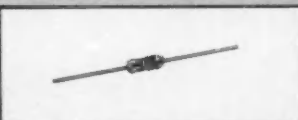


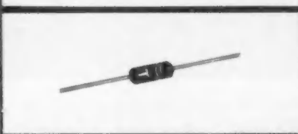
	Voltage Range (Volts)	Maximum Dynamic Resistance (ohms)	Maximum Current @ 25°C (ma)	@ 125°C (ma)	FEATURES
Subminiature — SV-5	4.3-5.4	55	50	10	• Long-term stability • Operation up to 150°C • Small size, easy mounting • Hermetically sealed
Miniature — SV-815	13.5-18	120	40	8	
Power — SV-924	20-27	8	55°C (amps)* .4	(ma)* 100	
Stabistor — SG-22	.64	40	150	25	
Reference — SV-3176	8-8.8	15	Temp. Coefficient ±.001%/°C		
Ref-Amp — 3N44	8.3-9.8		±.002%/°C		

*Case temperature ratings.

Write for Bulletin TE-1352

SILICON CAPACITORS

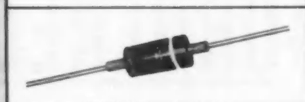




Ultra High Frequency Types — Ratings @ 25°C	Cut-off Freq. (mc)	Capacity (μμf) @ V Max.	@ −0.1V	Q @ −4V @ 50Mc	@ 100Mc	Maximum Working Voltage	FEATURES
SCH-51	5000	.35	2	100	50	10	• Subminiature Size • High Q • High Temperature Operation
SCH-52	5000	.8	4	100	50	7	
High Frequency Types				Q @ −4V At 5mc	At 50mc		
SC-1		4.4	24	350	35	22	
SC-5		25	120	350	35	11	
SC-15		120	360	350	35	6	

Write for Bulletin PB-45

GERMANIUM DIODES



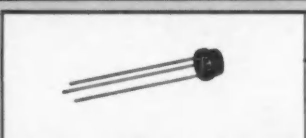
Specifications and Ratings at 25°C	Forward Current @ +1V (ma)	Inverse Current at Specified Voltage (μa @ V)	Max. Oper. Voltage (volts)	Description
JAN-1N270	200	100 @ −50	80	JAN TYPES
JAN-1N277	100	250 @ −50 @ 75°C 75 @ −10	100	JAN TYPES
JAN-1N281	40	500 @ −50 30 @ −50	60	JAN TYPES
JAN-1N126	5	500 @ −50 30 @ −10	60	JAN TYPES
JAN-1N198	5	250 @ −50 @ 75°C 75 @ −10	50	JAN TYPES
1N283	200	20 @ −10	20	COMPUTER TYPES
T16G	40	100 @ −50	60	COMPUTER TYPES
1N278	20	125 @ −50 @ 75°C	50	HI-TEMPERATURE TYPES
T22G	40	20 @ −10 @ 75°C	15	HI-TEMPERATURE TYPES
T9G	100	20 @ −50 2 @ −10	60	HI-RESISTANCE TYPES
1N67A	5	50 @ −50 5 @ −5	80	HI-RESISTANCE TYPES
T8G	100	20 @ −100 5 @ −10	100	HI-RESISTANCE TYPES
S570G	10	30 @ 6	Recovery Time .002 (μsec)	MILLI-MICROSECOND SWITCHING

FEATURES

- Milli Microsecond Switching
- Superior Forward Conductance
- High Inverse Resistance
- Uniformity and Stability
- Gold Bonded Construction

Write for Bulletin TE-1300 & TE-1319

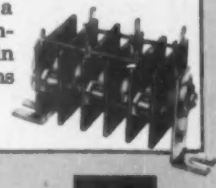
GERMANIUM COMPUTER TRANSISTORS



	Minimum Current Gain (B)	Maximum Collector Voltage (volts)	Typical Cutoff Freq. (MC)	FEATURES
2N427	40	15	8	• High Frequency Switching • Low Saturation Resistance • Uniform Input Characteristics
2N428	60	12	13	

Your local authorized TRANSITRON DISTRIBUTOR now carries in-stock inventories for immediate delivery.

Transitron's TD series of rectifier stacks offer a wide range of ratings in seven standard circuit configurations. High voltage cartridges, quads, plug-in assemblies, and many other special encapsulations are also available. Your inquiries are invited.
Write for Bulletin TE-1342.



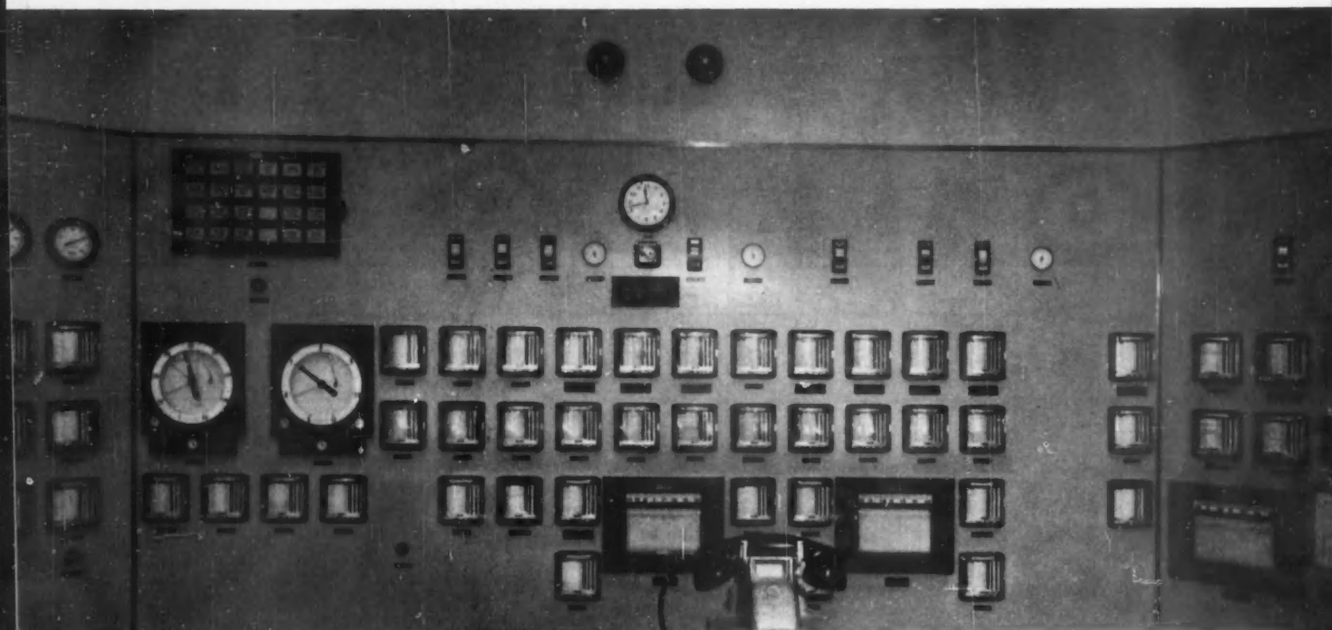
Transitron

electronic corporation • wakefield, massachusetts

CIRCLE 55 ON READER SERVICE CARD

Control panels for the Ethylene Oxide and Ethylene Glycol Units at Jefferson Chemical's Port Neches plant. Scientific Design Company Inc. handled design and detailed engineering for the Oxide Unit. C F Braun & Co were responsible for procurement and construction of both units, and the engineering for the Glycol Unit.

JEFFERSON CHEMICAL RE-ORDERED



Part of the hexagonal control room for Jefferson's Ethylene Unit A-2, where refinery gases are cracked to yield high purity ethylene and propylene. Designed and built by Stone & Webster Engineering Corporation, this unit tripled Jefferson's ethylene capacity. Process control by Taylor Instrument Companies.

HERE'S WHY:

"Smoothest unit start-ups ever experienced"

"A very minimum amount of instrument trouble was experienced"

"Instrument maintenance is at an all-time low"

"Transcope line of instruments is as versatile as we have ever used"

"Dollar for Dollar value, Transcope instruments are one of the most advanced designs offered today"

TAYLOR TRANSCOPE* INSTRUMENTS

The statements above, and many other equally complimentary comments, were made by the Instrument Engineer at Jefferson Chemical Co., Inc., Mr. J. W. Rutledge. He's referring to the performance of TRANSCOPE instrumentation at the Port Neches plant, first on the Ethylene Unit A-2 and later on the Ethylene Oxide and Ethylene Glycol Units.

In Mr. Rutledge's own words: "The new Taylor TRANSCOPE instruments were purchased for subsequent expansion, due to the fine performance of these instruments on our previous unit start-ups and the smooth operation of the operating units, as well as the low initial cost".

The photographs at left show a few of the several hundred TRANSCOPE Plug-in Recorders in use at Port Neches. In addition, Jefferson Chemical use many TRANSCOPE Indicators and Controllers and TRANS-AIRE* Temperature Transmitters.

"Never before so many features in so little panel space", has been our claim for the 90J Transcope Recorder since first introduced. The experience of Jefferson Chemical, and of many other companies in the chemical, petroleum and petro-chemical field all over the world is, we believe, eloquent "proof of the pudding".

To learn more about the truly remarkable—and many unique—features of the TRANSCOPE instruments, call your Taylor Field Engineer; or write for **Bulletin 98286.** Taylor Instrument Companies, Rochester, N. Y., or Toronto, Ont.

*Reg. U.S. Pat. Off.

Taylor Instruments **MEAN ACCURACY FIRST**

CIRCLE 57 ON READER SERVICE CARD

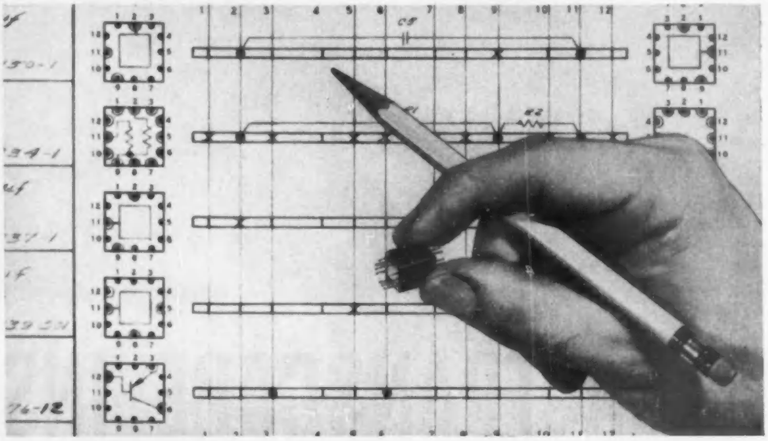
Status Report on RCA Micromodules—
dramatic new devices for high-density parts packaging

How soon will you see your electronic products in Micromodule form?

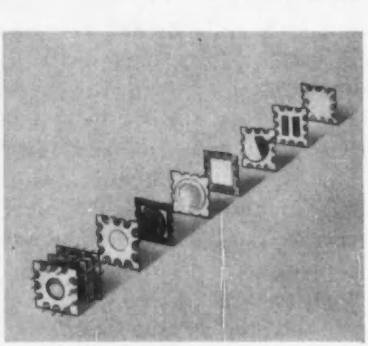
The excitement over Micromodules is still mounting! We haven't seen such enthusiasm and activity since the early days of transistors. Scores of electronic equipment designers and manufacturers are asking: "How soon can I see my product in Micromodule form?" Our answer: *Right Now!* We'll take your circuit, breadboard, or black box, evaluate it and convert it to module form. In fact, you will find that end-equipment in Micromodule form is probably only *one design cycle away!*

Special Presentation Now Ready!

RCA Field Engineers are prepared to show you a presentation that will clearly explain the potentialities and the current working realities of Micromodules for application in military computers, digital devices for missiles and satellites, airborne or portable communication equipment, or submarine electronics. Many designers who have seen this presentation were so impressed with the possibilities of extreme miniaturization and increased reliability of Micromodules that they have immediately placed orders to begin micromodularization of their equipment. Call your RCA Field Representative today and he will set up a presentation for you at your convenience.



RCA Micromodules, todays' most exciting, most practical answer to high-density parts packaging, make possible equipment with modular parts densities to 600,000 per cubic foot. Result: important space savings over existing miniature equipment and an amazing increase in the *number of circuit functions* per cubic foot. Increased reliability through redundancy, room for more circuits to improve accuracy, precision, control and sensitivity are other significant advantages offered to designers.



Micromodules, developed through the joint efforts of RCA and other leading component manufacturers, in cooperation with the U.S. Army Signal Corps, are units in which several microelements are combined to perform specific functions such as amplifier, oscillator, or divider. The microelements are tiny ceramic wafers .310 inches square and 1/100th inch thick, on which conducting, semiconducting, and insulating materials are fused to provide the electrical characteristics of basic electronic components such as resistors, capacitors, and transistors. The microelements are interconnected and encapsulated to form Micromodules.

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HUmboldt 5-3900
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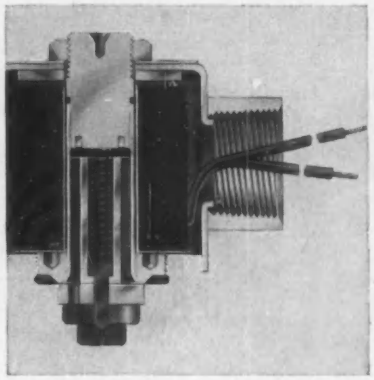
ALSO AVAILABLE AT YOUR LOCAL RCA SEMICONDUCTOR DISTRIBUTOR

RADIO CORPORATION OF AMERICA
SEMICONDUCTOR & MATERIALS DIVISION • SOMERVILLE, N. J.

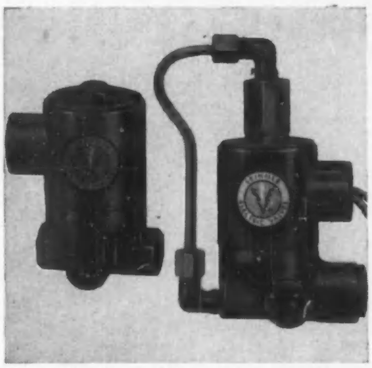
Skinner introduces Two-Way Solenoid Valve for Control of High Pressures

New High Pressure Models just added to the Skinner two-way Type R series line of pilot-operated solenoid valves are offered in two-way normally closed construction only. Orifice size is ¼" diameter with ¼" NPT ports. Operating pressure differentials: 5 to 1250 psi on AC voltages and 5 to 1000 psi on DC voltages. Designed for use with such media as air, oil, water and semi-corrosive liquids.

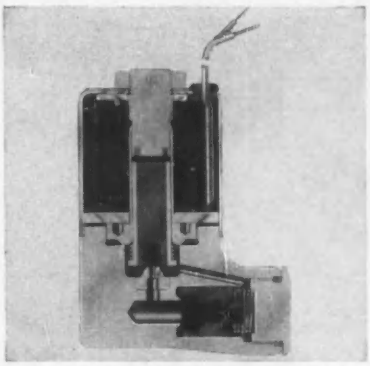


Features. New Skinner Models are built to U. L. requirements in standard and explosion-proof construction. V5-2H type solenoid operator contains stainless steel internal parts to resist corrosion. Valve body is forged naval brass and contains stainless-steel piston assembly, precision machined to close tolerances for positive opening and closing of the main orifice.

Variety of Coil Voltages. Standard coils, built to U. L. standards, are varnish-impregnated and moisture-resistant. Molded waterproof coils are available that will even operate under water and are resistant to fungus growth. Coils are available in wide range of voltages and frequencies.



Standard Pressure Two-way R Series Valves. These two-way valves are available in standard and explosion-proof construction, normally open or normally closed. Pressure operating differentials are 5 to 200 psi for normally closed and 5 to 150 psi for normally open.



Many Desirable Features: Standard pressure R series two-way valves have V5 type operator; stainless steel internal parts; naval brass body; stainless-steel piston assembly; soft synthetic inserts for bubbletight operation. Normally open models have piped-body return. Valve can be mounted in any position.

Custom Installation with these Options. There is a large selection of electrical housings that can be rotated 360° for easy connecting. Also available is manual override that permits opening or closing the valve in the event of current failure.

Skinner Solenoid Valves are distributed nationally.

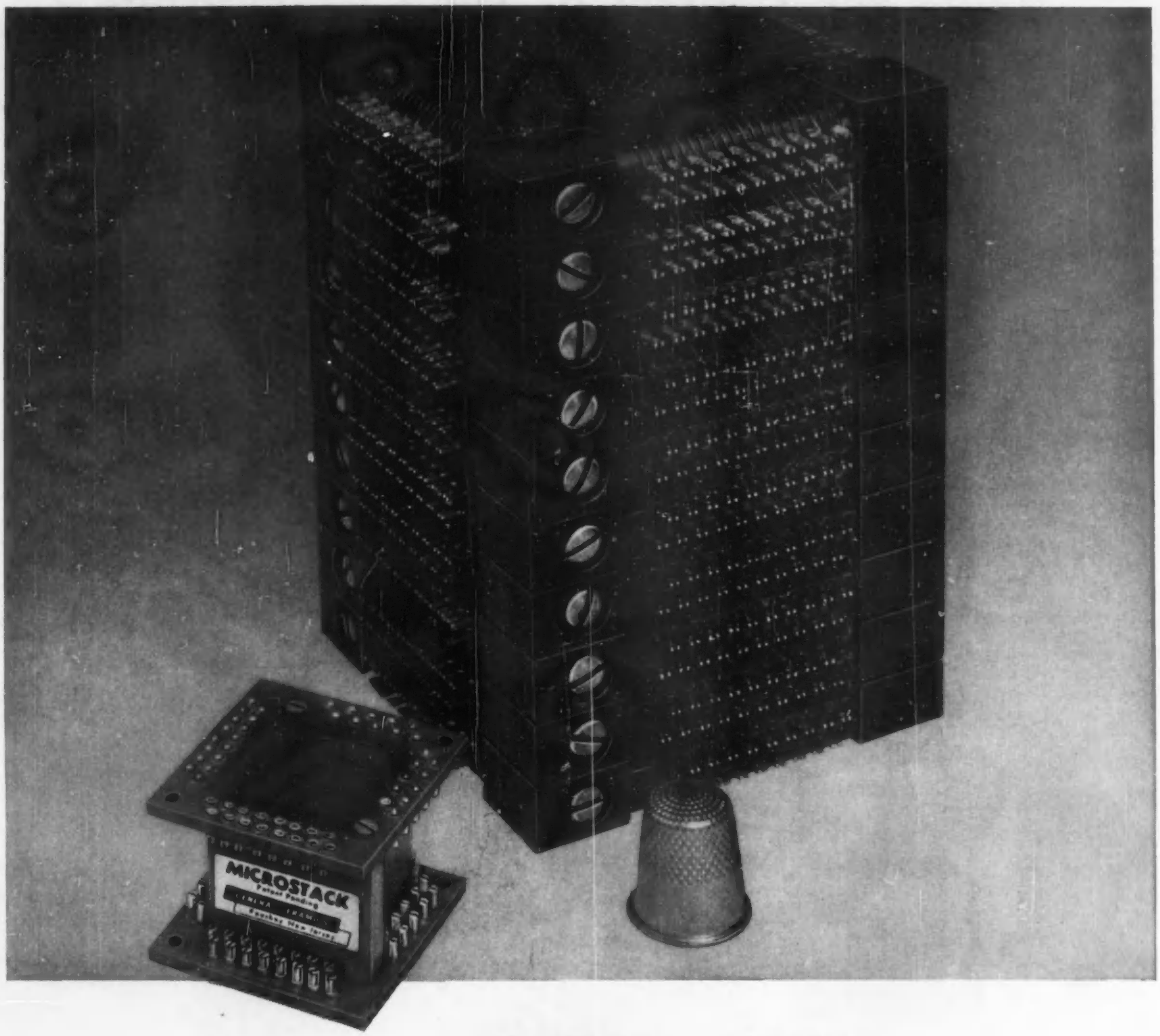
For complete information, contact a Skinner Representative listed in the Yellow Pages or write us at Dept. 34D.

SKINNER ELECTRIC VALVES

THE CREST OF QUALITY THE SKINNER ELECTRIC VALVE DIVISION • NEW BRITAIN, CONNECTICUT

CIRCLE 59 ON READER SERVICE CARD

Designing in miniature? Here's how to save space—



...90% of it!

New G-C MICROSTACK* for coincident current memory systems has a physical volume just 10% that of conventional stack. MICROSTACK shown with 2560 cores measures only 1.125" x 1.4" x 1.4", a reduction in size from 3½" x 3½" x 5".

This miniature stack consists of an array of 16 x 16 x 10. Solder connections are greatly reduced (from 1192 to 104), thereby substantially increasing reliability.

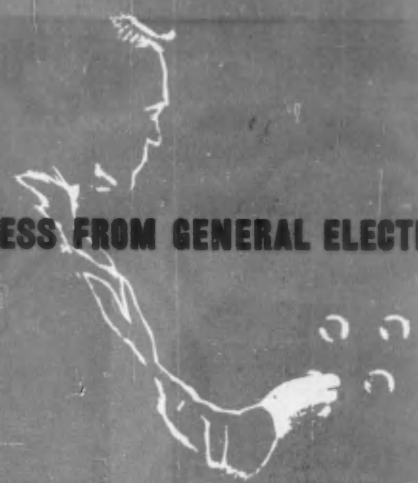
Noise level in the new MICROSTACK is as low as that of conventional types. The new MICROSTACK is available with all standard memory cores. Standard packages are available with coincident current wiring in 10 x 10 x 8, 16 x 16 x 8 and 32 x 32 x 8 arrays.

For further information, please write on company letterhead—address inquiries to Dept. CE.

*Trademark

GENERAL CERAMICS
ORIGINATOR OF THE SQUARE LOOP FERRITE

General Ceramics Corporation
KEASBEY, NEW JERSEY, U.S.A.



COMPUTER PROGRESS FROM GENERAL ELECTRIC

Two More Users Agree:

THE GE 307 MINIATURIZED NETWORK ANALYZER PAYS FOR ITSELF SOLVING TRANSMISSION AND DISTRIBUTION PROBLEMS

Utah Power and Light Company engineers R. W. Moody (l.) and G. Wilkinson use the GE 307 Miniaturized AC Network Analyzer to solve a typical problem in transmission. "It saves many engineering man hours in delivering solutions to problems involving engineering alternatives."

Kansas Power and Light Company engineers A. A. Liepa and J. D. Wallace use the GE 307 Analyzer in system voltage study, only one of the many applications. The GE 307 Analyzer "eliminates laborious calculations . . . we just set up the problem and determine answers quickly, efficiently," says engineer A. A. Liepa.

Again, G-E custom computer design delivers! In this instance, speeding solutions *right now* to problems too large for hand calculation, too small for the expense of large network analyzer solution. The Miniaturized Analyzer proves quick solutions for the following everyday, but must-be-solved problems:

- Studying such system voltage conditions as regulator capacitor requirements and determining corrections.
- Checking loadings on lines and cables.
- Investigating adequacy of presently installed, or future circuit breakers.
- Analysis of transmission requirements to supply new loads.

Request brochure CPB-4B. Contact your nearest General Electric Apparatus Sales Division Office, or write to: Computer Department, General Electric Company, Deer Valley Park, Phoenix, Arizona, Room 550

Progress Is Our Most Important Product

GENERAL ELECTRIC

FOR FIGURES IN A HURRY—FIGURE ON A GE COMPUTER

CIRCLE 61 ON READER SERVICE CARD

CPA-22 (11-59)

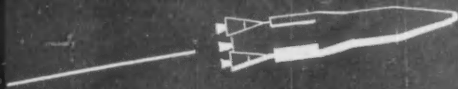
Reeves
INSTRUMENT CORPORATION

Subminiature Computers

MODULAR DESIGN

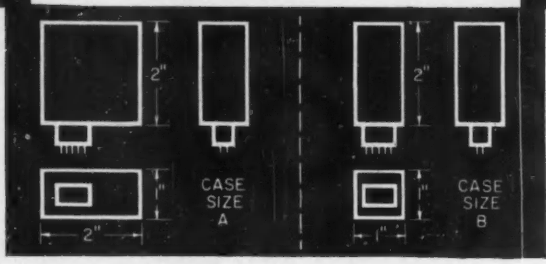
- COMPUTER AMPLIFIERS
- COMPUTER CONTROL SYSTEMS

Actual Size



MISSILE-PROVEN AND TESTED

FULLY DESIGNED AND DEVELOPED TO MEET APPLICABLE MILITARY SPECIFICATIONS



AVAILABLE TYPES

AMPLIFIER	Case Size	AMPLIFIER	Case Size
Resolver Drive Amplifier	B	A-C Amplifier	A
A-C Summing Amplifier	A	D-C Amplifier	A
A-C Isolation Amplifier	A	Pulse Amplifier	A
AGC Amplifier	A	ADC Drive Amplifier	B
Relay Amplifier	A	Pulse Power Amplifier	A
Servo Preamplifier	A	Accumulator Amplifier	A
Servo Power Amplifier	A	Electronic Differential	A

Diode Synchro Signal Selector

DESIGN FEATURES

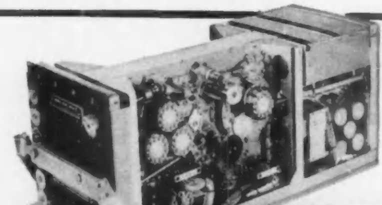
- Completely encapsulated for continued reliability under extreme environmental conditions
- Plug-in modular design for rapid assembly and ease of maintenance
- Fully transistorized—Minimum Weight and Volume
- Cadmium-plated steel casings for electrical shielding
- Meet MIL specifications: MIL-E-8189 and MIL-E-5400, Classes I and II

Write on company letterhead for complete Data File No. 112.

COMPLETE COMPUTER SYSTEM PACKAGES

- Mid-Course Missile Computers
- Inertial Reference Packages
- Stable Platforms
- Rate Loops

REEVES' contributions to such advanced missile programs as DISCOVERER, TITAN and REGULUS are your assurance of proven reliability and performance.



12RV59

Qualified engineers seeking rewarding opportunities in this and other advanced fields are invited to get in touch with us.

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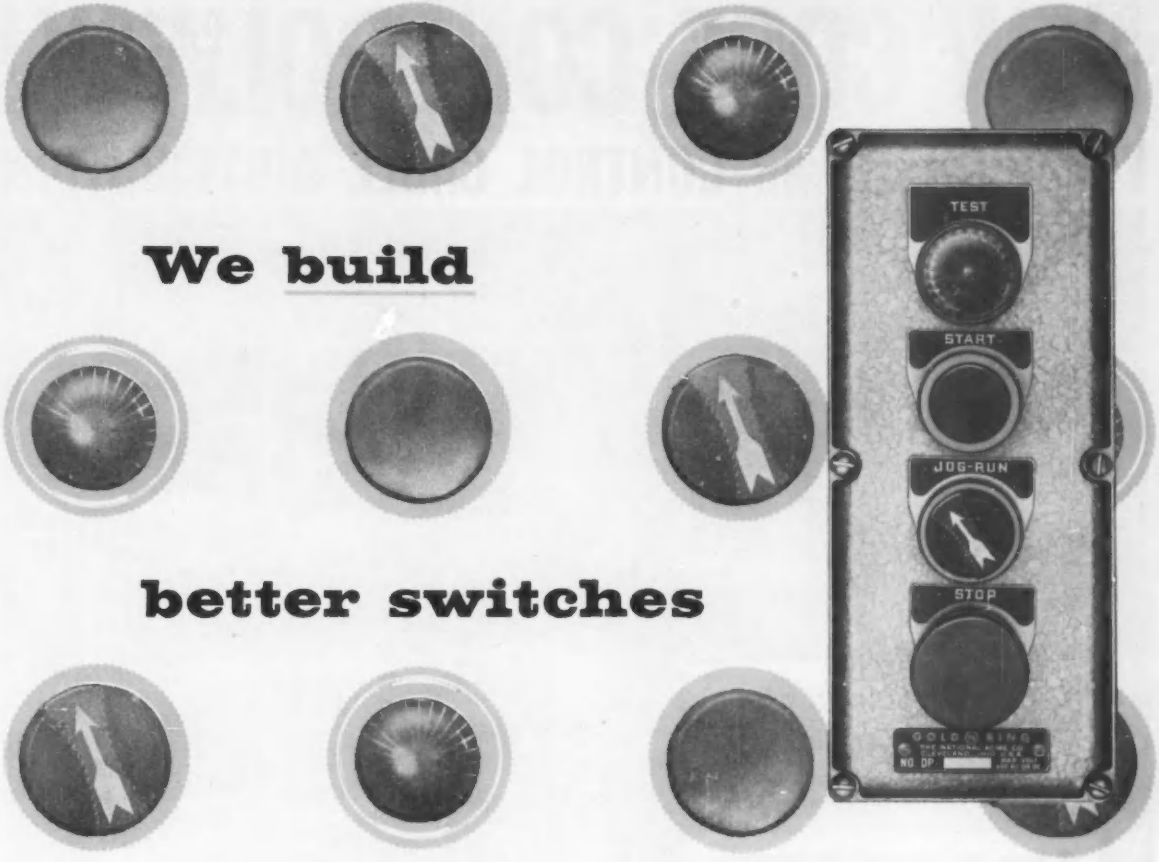


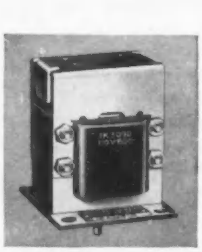
We build better switches because we can't buy them

...IT'S AS SIMPLE AS THAT...AND THEY COST NO MORE THAN OTHER SWITCHES

We had to build Gold-N-Ring Control Switches to meet our own high reliability specifications . . . our reputation was a part of this important fact. We're machine tool builders. We can't afford to be responsible for costly down-time on important capital investment equipment due to inferior control switches That's why we build them like precise machine tools . . . and why it will pay you to check with us.

A wide range of basic units meets practically every need . . . as well as completely assembled stations in 1 to 4 button sizes to meet your electrical specifications. Ask our representative to call, or send for Bulletin ECS-56 . . . the complete selection and ordering guide.

LIMIT SWITCHES. A full line, originally designed for machine tool applications but now used wherever the highest reliability factors are required. Bulletin EM-51.



SOLENOIDS. A full line of standard and custom units for AC or DC. Push or pull types with capacities up to 25 lbs. Bulletin EM-52A.

ELECTRICAL MANUFACTURING DIVISION

National Acme

THE NATIONAL ACME COMPANY
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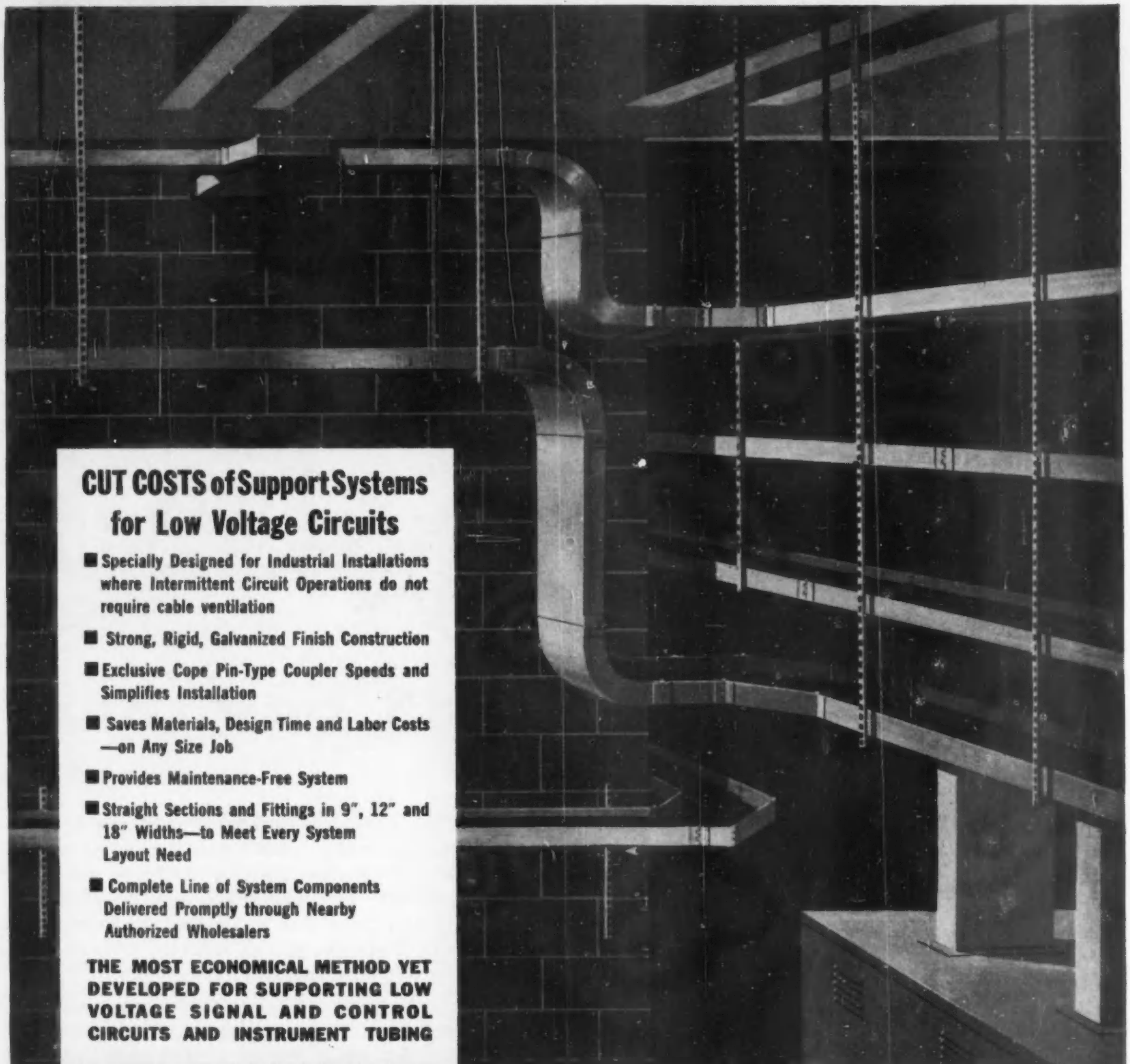
CIRCLE 63 ON READER SERVICE CARD

NEW COPE CONTROLWAY!

FOR SIGNAL AND CONTROL CABLE DISTRIBUTION



CUT COSTS of Support Systems for Low Voltage Circuits

- Specially Designed for Industrial Installations where Intermittent Circuit Operations do not require cable ventilation
- Strong, Rigid, Galvanized Finish Construction
- Exclusive Cope Pin-Type Coupler Speeds and Simplifies Installation
- Saves Materials, Design Time and Labor Costs—on Any Size Job
- Provides Maintenance-Free System
- Straight Sections and Fittings in 9", 12" and 18" Widths—to Meet Every System Layout Need
- Complete Line of System Components Delivered Promptly through Nearby Authorized Wholesalers

THE MOST ECONOMICAL METHOD YET DEVELOPED FOR SUPPORTING LOW VOLTAGE SIGNAL AND CONTROL CIRCUITS AND INSTRUMENT TUBING

ASK FOR PROOF! Get cost saving details on new Cope Controlway from your Authorized Cope Electrical Wholesaler *today*. For illustrated brochure describing system design features and installation advantages, write direct to T. J. Cope, Division of Rome Cable Corporation, Collegeville, Pa.

COPE CONTROLWAY IS SOLD ONLY THROUGH AUTHORIZED ELECTRICAL WHOLESALERS

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COPE

Originators of First Integrated Line of Cable Supporting Systems
WIREWAY • LADDER • CHANNEL • CONTROLWAY

Division of ROME CABLE CORPORATION
COLLEGEVILLE, PENNSYLVANIA

IF INSTALLED-COST IS A DESIGN PROBLEM

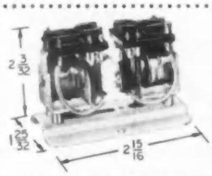
Look at the KA general purpose RELAY

What do your relays cost *installed?* Initial cost is never the whole story.

Our KA Relays are engineered for modern production methods. They're available with printed circuit, taper tab, quick-disconnect or hook solder terminals . . . are simple, economical to install. This fact, combined with low original cost, keeps your total cost down.

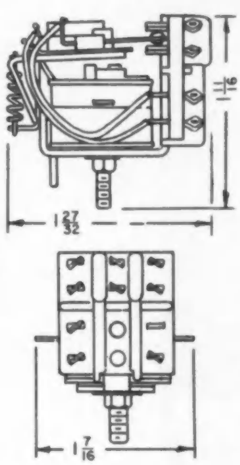
Another source for savings! All standard KA ac relays bear U/L and Canadian Standard Association seals of approval.

Write or call for more information or see the complete P&B catalog in Sweet's Product Design File.



KB LATCHING RELAY consists of two KA Relays, forming a mechanical latching relay, featuring a large number of contact arrangements.

KA ENGINEERING DATA



GENERAL:

Insulation Resistance: 100 megohms min.
Breakdown Voltage: 1500 V. rms between all elements.
Temperature Range:
−55° C. to +85° C. DC
−55° C. to +70° C. AC
Weight: 2.0 ozs.
Pull-In: DC 75% of nominal voltage.
AC 78% of nominal voltage.
Terminals: Taper tabs.
Printed circuit.
Quick-disconnect.
Pierced solder lugs.
Enclosures: Dust Cover
(max. 55° C. ambient for AC relays)
(max. 70° C. ambient for DC relays)

CONTACTS:

Arrangements: 3 Form C (3PDT) max.
Material: Movable—1/8" silver; stationary—5/32" wide silver overlay.
Load: 5 amps @ 115 V. AC 60 cps res.

COILS:

Resistance: 16,500 ohms max.
Power: 1.2 watts (DC), 2 volt amps (AC)
Duty: Continuous AC or DC (DC coils will stand 4.5 watts at 25° C.)

P&B STANDARD RELAYS ARE AVAILABLE AT YOUR LOCAL ELECTRONIC PARTS DISTRIBUTOR

POTTER & BRUMFIELD

DIVISION OF AMERICAN MACHINE & FOUNDRY COMPANY, PRINCETON, INDIANA

IN CANADA: POTTER & BRUMFIELD CANADA LTD., GUELPH, ONTARIO

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Through Haydon Research...

BETTER ANSWERS TO YOUR TIMING PROBLEMS TODAY *and* TOMORROW!

An important part of Haydon's Research and Development Program concerns itself with your *immediate* timing requirements . . . analyzing the timing problems you submit, investigating all possible methods of solution, and developing new timers — or adapting existing models . . . to meet your needs exactly.

However, an equally important part of our Research and Development Program is concerned with *anticipating* your future timing requirements — and with deyeloping in advance the new timing methods and devices that will provide the solutions. In conducting this latter part of our research, we carry out an extensive program at our own complete in-plant laboratory . . . and also take full advantage of the advanced experimental data developed in the laboratories maintained at New York and Chicago by General Time Corporation, our parent organization.

Concerned primarily with "pure" research, the New York laboratory investigates the latest advances in all the basic sciences to determine which have possible application in the field of timing and timing control. The Chicago laboratory concerns itself with applying timing to military and industrial fields. Finally, our own laboratories at Haydon determine how these new timing principles can be applied to the development and manufacture of practical, dependable, economically priced new timing motors and devices that will solve *your* present and anticipated timing problems.

As a result of this triple-team program of research and development, covering every stage from pure science to practical production, you can *always* count on Haydon to provide the latest and finest for your timing needs . . . today, tomorrow and *any* time!

For further information, write now, outlining your timing requirements, or contact your nearest Haydon field engineer.

Haydon
AT TORRINGTON

Division of General Time Corporation

2336 EAST ELM STREET, TORRINGTON, CONNECTICUT

Headquarters for Timing

now there are 3

Honeywell, developers of the
original VISICORDER Ultra Violet
recording oscillograph principle,
now brings you a third
great Visicorder oscillograph . . . the

**MODEL 1108 24-CHANNEL DIRECT-RECORDING
VISICORDER OSCILLOGRAPH**

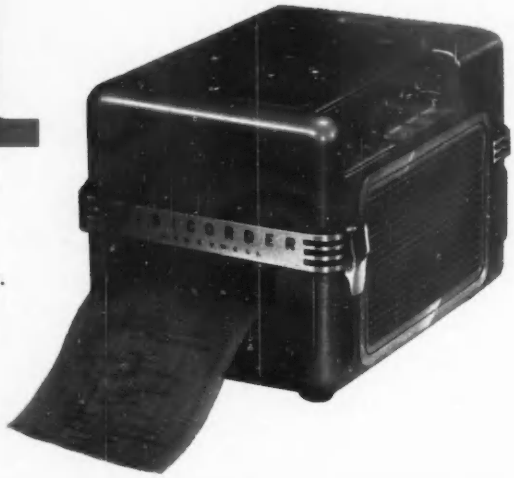
H
HONEYWELL

1

MODEL 906 VISICORDER

The original 8-channel Model 906 Visicorder was the first oscillograph to make use of the now-famous Ultra-Violet Visicorder recording principle, pioneered and developed by Honeywell. The 906 Visicorder was the first oscillograph to combine the high frequency response and writing speed of photographic-type oscillographs with the convenience of direct recording. Recent models incorporate time lines and grid lines, and record up to 14 simultaneous channels of data at frequencies from DC to 5000 cycles per second.

The 906 Visicorder is ideal for uses requiring up to 14 channels of data.



THE NEW MODEL 1108 VISICORDER OSCILLOGRAPH

3

Fitting neatly between the 14-channel 906 and the 36-channel 1012, the new 24-channel Model 1108 gives you direct writing Visicorder oscillography at the *lowest cost per channel*.

Like all Visicorders, the Model 1108 was designed from the base up to make the fullest use of the completely proven and unsurpassed Visicorder principle. The new 1108 also directly records at frequencies from DC to 5000 cycles per second at sensitivities comparable to photographic oscillographs. Like the Model 1012, the 1108 incorporates many automatic features and the years-ahead convenience of pushbutton controls.

The Model 1108 Visicorder, the most modern intermediate-size recording oscillograph on the market today, is ideal for intermediate uses requiring up to 24 channels of data.

2

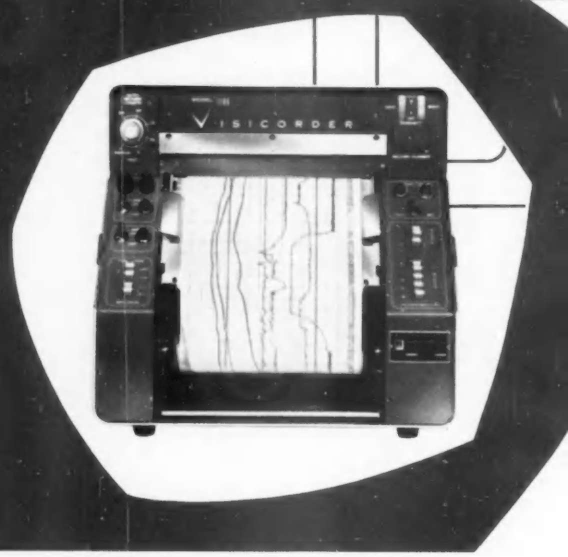
MODEL 1012 VISICORDER

The Model 1012 Visicorder is the most versatile and convenient oscillograph ever devised for converting as many as 36 simultaneous channels of dynamic data into immediately-readable records. Like other Visicorders, the 1012 permits monitoring the information at the recording point as it goes on the record. It also records at frequencies from DC to 5000 cps.

The Model 1012 Visicorder, with its conveniences and broad capacities, is ideal for large-scale uses where up to 36 channels of data are required.

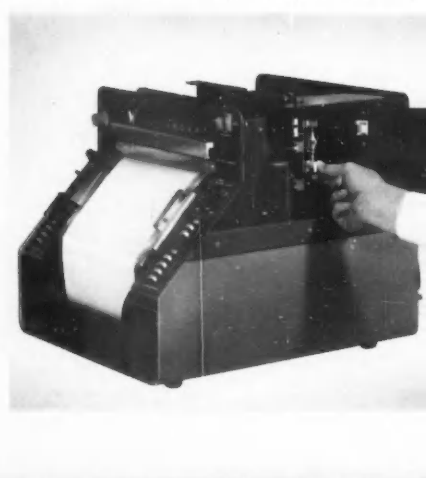
NEW MODEL 1108 VISICORDER provides the ultimate in im unlimited variety of applications.

The Model 1108 may be used in direct connection with many types of transducers where high frequency recordings are not required. Or it may be teamed with various types of amplifiers where high-frequency—high amplitude readout is desirable. A broad selection of galvanometers with a wide variety of sensitivities and frequencies is available. A schematic diagram designed to suggest sample hookups for various applications—with and without amplification—appears at lower right, and demonstrates the wide variety of uses to which this one recording system may be put.

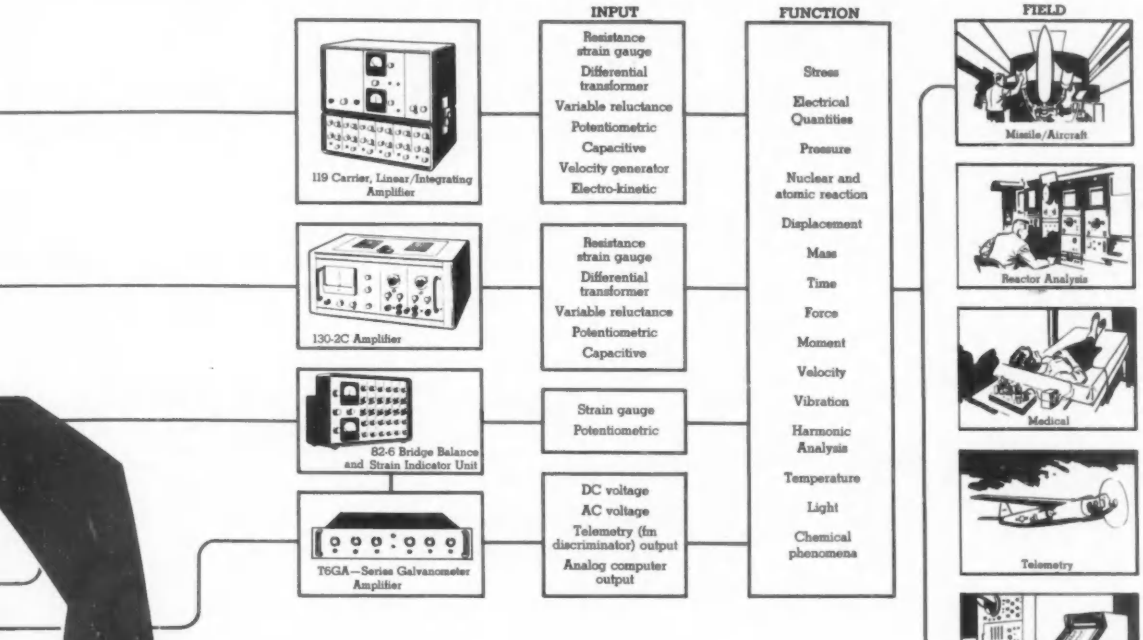


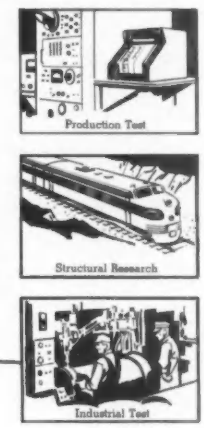
EASY PAPER LOADING . . . *Paper supply assembly swings forward, supply roll drops easily into place. No threading required.*

CONVENIENT ACCESS . . . *Covering panels on cleaning of optical components, calibrating timer, and REAR VIEW shows rear-panel input connectors.)*



e in immediate, convenient readout of data in an





MODEL 119 *Carrier Amplifier System ... primarily for resistive, variable reluctance and differential transformer type transducers. Linear and Integrating Amplifiers may replace Carrier units in the case. Frequency response: (Carrier) 0-1000 cps; (linear/integrate) 5-5000 cps. Six channels.*

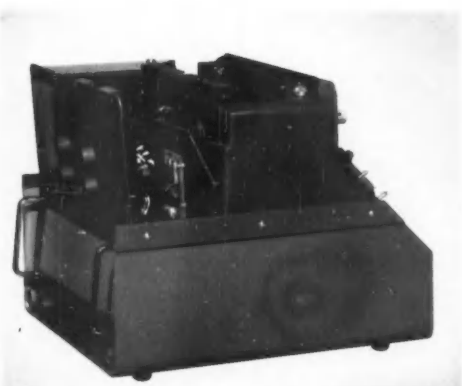
MODEL 82-6 *Bridge Balance and Strain Indicator Unit... controls, calibrates and measures static and dynamic phenomena from resistive transducers. Gives full indication on meter scale with as little as 315 uin/in strain input. Six channels.*

MODEL 130-2C *Amplifier System ... amplifies output of transducers measuring strain, force, acceleration, flow, pressure, control, displacement, and many other phenomena. Two channels.*

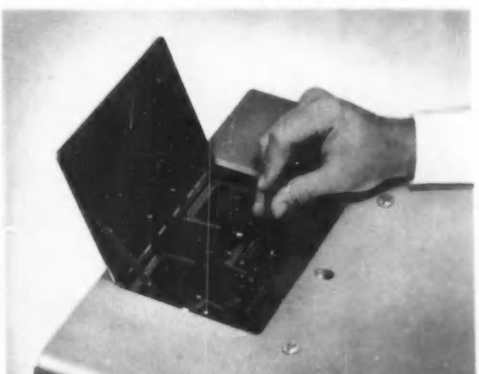
MODEL T6GA *DC Amplifier System ... a compact 3-stage transistor amplifier which operates the high-frequency Visicorder directly from low power inputs down to 1 volt. Six channels.*

SERIES "M" *Subminiature Galvanometer ... features minute, sealed construction, higher sensitivity, greater stability. Directly interchangeable in Honeywell Models 1108, 1012, 906A-1, and 906B-1 Visicorders and Models 708C and 712C developing-type oscillographs.*

ing panels on instrument are readily removable for easy access to lamp, ing timer, and to service other assemblies. (THREE-QUARTER connectors.)



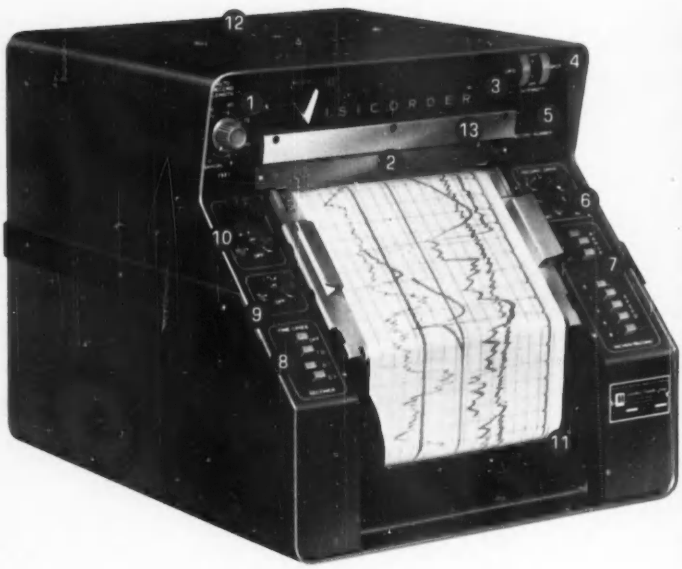
EASY GALVANOMETER ADJUSTMENT . . . *provided through top panel. No clamping or locking is required. Galvanometer spots may be observed at recording point while adjustment is being made.*



MODEL 1108 VISICORDER

adds still more versatility to the Honeywell family of direct recording oscillographs.

Designed to the utmost standards of customer convenience, high-frequency and high sensitivity recording, and reliable, accurate performance, the Model 1108 continues the long-standing tradition of Honeywell leadership through creative engineering. Examine the diagram below for feature-by-feature evidence of this leadership.



FEATURES OF THE 1108

General Features

1. **AUTOMATIC RECORD LENGTH CONTROL** . . . *adjustable from 1 to 25 feet . . . indicator shows amount of pre-set record length remaining.*
2. **VISIBLE RECORDING POINT** . . . *galvanometer spots may be monitored through amber screen as they record.*
3. **GRID LINE INTENSITY CONTROL** . . . *manually adjustable to compensate for exposure at various record speeds. (Grid line spacing: 0.1 inch; 5th line accentuated. Custom grid spacings on special order.)*
4. **GALVANOMETER SPOT INTENSITY CONTROL** . . . *off, on, and manually adjustable to control sharpness of galvanometer traces at various record speeds and writing speeds.*
5. **RECORD NUMBERING** . . . *Four-digit resettable record-number counter photographed at start of each record. Flash-tube type; may also be used as event marker.*
6. **RECORD DRIVE CONTROL and INDICATOR** . . . *"Forward" for recording; "reverse" for closer study and analysis of data after recording has been made. Indicator signal light turns off if recording is not taking place.*
7. **RECORD SPEED INDICATOR**, *pushbuttons for 5 speeds plus 3 range pushbuttons give you 15 separate speeds. Speeds may be changed during operation. Positive clutches, no gear meshing.*
8. **TIME LINE SYSTEM** . . . *Electronic flash type, instant warmup. Three selectable intervals: 1, .1, and .01 seconds. No optical parallax. May also be operated from external signal and in multiplex.*
9. **RECORDING LAMP ON-OFF CONTROL AND INDICATOR**
10. **POWER ON-OFF CONTROL AND INDICATOR**
11. **RECORDING PAPER CAPACITY** . . . *8" x 200 feet of standard-weight paper; 350 feet of thin base paper. Take-up integral with record-drive system.*
12. **GALVANOMETERS** . . . *access through top panel. Accepts up to 24 Series M Subminiature galvos, plus 4 static reference galvos. Directly interchangeable among Honeywell Models 906A-1, 906B-1, 1012, 700C oscillographs.*
13. **PAPER KNIFE** . . . *manually operated.*

Other Features

TRACE IDENTIFICATION . . . *at 45° slope, 1/32" width, interrupting galvos in sequence on approximately 8" spacing.*

OPTICAL ARM . . . *11.8 inches (30cm) standard in all Honeywell oscillographs.*

LAMP AND CIRCUIT . . . *High-pressure mercury vapor lamp. Automatic starting.*

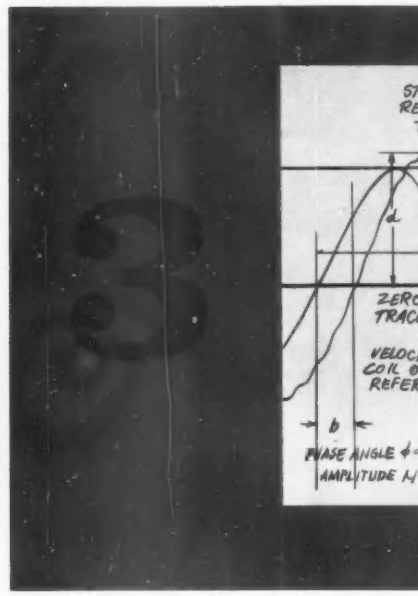
REMOTE OPERATION . . . *Control circuits provided for remote operation.*

INPUT POWER . . . *105-130 volts; 60 cycle; 7 amps. 50 and 400 cycle models also available.*

MOUNTING . . . *Table and rack. Shock or vibration mounting using available accessories.*

◀◀◀ *open this page*

TYPICA



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AND MON
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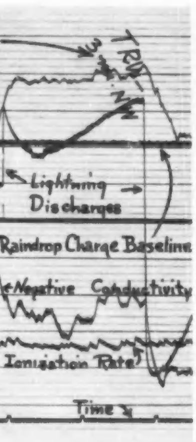
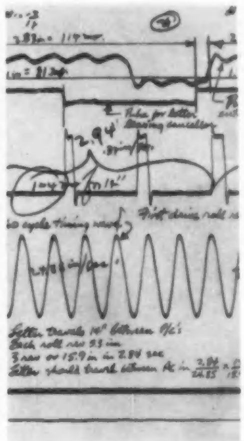
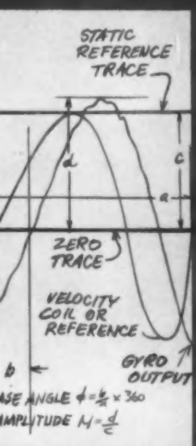
YPICAL USES OF THE VISICORDER



In weather research . . .
This Visicorder record gave U.S. Weather Bureau scientists immediate readout of thunderstorm data taken at Mt. Washburn in Yellowstone National Park. As the storm system passed, the Visicorder recorded positive and negative air conductivity, rate of ionization of air, raindrop charge, corona discharge current from an insulated tree and a 4′ x 6′ grass plot, times of camera exposure photographing droplet size and electrical charge, atmospheric potential gradient, and time.

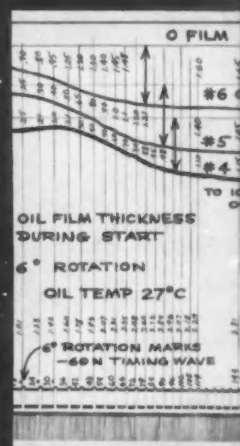
In development test . . .
This directly-recorded Visicorder record shows a canceller test of letters through a new mail-handling machine developed by Emerson Research Laboratories for the U.S. Postoffice Department.
The Visicorder test took only 3 hours to solve a 3-week problem: why letters, travelling at the rate of 30,000 letters per hour, changed speed as they went through the machine. (Constant speed is necessary to register cancellation on the stamp every time.) Motor speed variations, belt slippage, and letter slippage in the drive rollers were responsible. A synchronous-drive motor, a timing belt drive, and a better grade of rubber in the drive rollers were added to solve the problem at a vast saving in engineering time.





In production . . .

Industrial design . . .



OTHER USES of the Model 1108 Visicorder . . . as a direct readout unit IN RECORDING ND MONITORING SYSTEMS . . . IN MISSILE AND ENGINE ANALYSIS for test stand recording . for analog recording OF TELEMETERED SIGNALS . . . IN CONTROL to monitor reference and ror signals . . . IN NUCLEAR TEST to record temperatures, pressures, impacts, etc. . . . IN LAB-RATORIES for all purpose analysis . . . IN PRODUCTION for final dynamic inspection . . . IN COM-UTING for immediately-readable analog records . . . IN PILOT COMPONENT TESTS for rapid valuation of prototypes . . . IN ALL TESTS which are non-repetitive in sequence, making oscilloscopes npractical.

Honeywell

H Industrial Products Group

For further information including prices and delivery, write Minneapolis-Honeywell Regulator Company, Industrial Products Group, Heiland Division, 5200 E. Evans Ave., Denver 22, Colorado.

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Specify the Finest Digital Voltmeter Made

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When the combination of reliability, speed and accuracy is of uncompromising importance—you can't afford to gamble on "second best" digital measuring equipment! NLS Series 20 instruments are field-proven in the most critical applications—missile and electronic systems checkout, automatic process monitoring, sophisticated laboratory research. Be sure—specify NLS Series 20, the instruments selected by major missile manufacturers after thousands of hours of competitive life testing.

Features: M24 measures DC voltage, voltage ratio or resistance in a third of a second, V24 measures DC voltage and voltage ratio at same speed . . . both instruments feature advanced transistorized circuitry and mercury-wetted relays with life in excess of 3 billion readings . . . ±one digit accuracy on DC voltage and voltage ratio . . . completely automatic operation . . . plug-in modular construction . . . AC or low level measurements with plug-in accessories . . . output connectors for continuous data logging, remote ranging. Ranges: DC voltage ±.0001 to ±999.9; DC voltage ratio to ±.9999; resistance .1 ohm to 1 megohm. Write today for complete data.

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Originator of the Digital Voltmeter

non-linear systems, inc.

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NLS — The Digital Voltmeter That Works . . . And Works . . . And Works!

CAREER OPPORTUNITIES AT TI

DEVICE DEVELOPMENT ENGINEER

26,000 TI transistors will be produced from slices of germanium crystal seen in container above being inserted into diffusion furnace. Magnified in circle above are 37 of more than 1,000 transistor hearts per slice.

your future:
a challenging opportunity with an industry leader

Now take advantage of maximum professional growth at Texas Instruments by participating in development of the most advanced semiconductor-component devices. Working with the newest facilities, take part in:

- **DEVICE DEVELOPMENT** Development of new devices by studies in solid-state diffusion, alloying of metals and semiconductors, vacuum deposition of metals, surface chemistry, and solid state physical measurements.
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With TI, receive liberal company-paid benefits, including profit sharing *(last year 15% of base salary)*.

Interviews will be held in your area soon. If you have an Electrical Engineering, Physical Chemistry or Physics degree and experience in semiconductor or related development areas, please send a resume to:

W. T. Hudson, Dept. 201-E-CE
(for immediate Eastern appointment)
1141 E. Jersey Street, Elizabeth, New Jersey

or

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TI 2N337 SERIES USE-PROVED IN ADVANCED APPLICATIONS

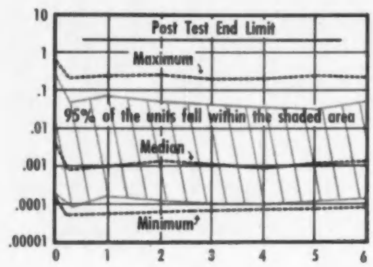
Now get advanced application information and complete reliability and life-test data on TI grown-junction silicon transistors—based on four years' experience.

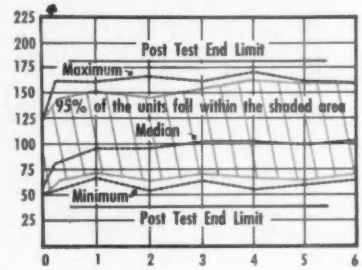
PARAMETER TEST CONDITIONS AND LIMITS

PARAMETER MEASURED	TEST CONDITIONS	ACCEPTANCE LIMIT	
		MIN	MAX
I_{CBO}	V_{CB} = 20 vdc, I_E = 0, T_A = 25°C	—	2 μa

PARAMETER TEST CONDITIONS AND LIMITS

PARAMETER MEASURED	TEST CONDITIONS	ACCEPTANCE LIMIT	
		MIN	MAX
h_{FE} pulse	V_{CE} = 5 vdc, I_C = 10 ma, T_A = 25°C	45	150





I_{CBO} and h_{FE} characteristics of a sample of 60 TI 2N337 and 2N338 units over a 6-week period. These tests are conducted by TI's independently operated Quality Assurance Branch, and are representative of the complete parameter behavior test information in the Silicon Transistor Reliability Data brochure listed below.

PUSH-PULL TRANSISTORIZED SERVO AMPLIFIER

Description of a 2-watt transistorized servo amplifier which, using unfiltered rectified a-c for the collector supply, has high collector efficiency.

HIGH-INPUT-IMPEDANCE AMPLIFIER USING SILICON TRANSISTORS

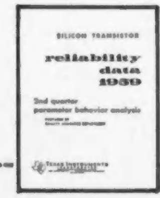
Amplifier described has input impedance of 8 megohms, voltage gain of 40 db, and output impedance of 600 ohms.

TRANSISTORIZED VOLTAGE REGULATOR CIRCUIT

Description of a circuit which can regulate the voltage to loads demanding up to 600 ma.

HIGH-FREQUENCY CHARACTERISTICS OF GROWN-DIFFUSED SILICON TRANSISTORS

Description of characteristics of 2N338 switching and general-purpose unit and 3N34 and 3N35 very-high-frequency tetrodes.

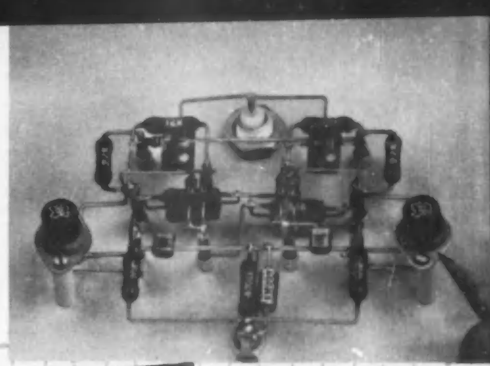


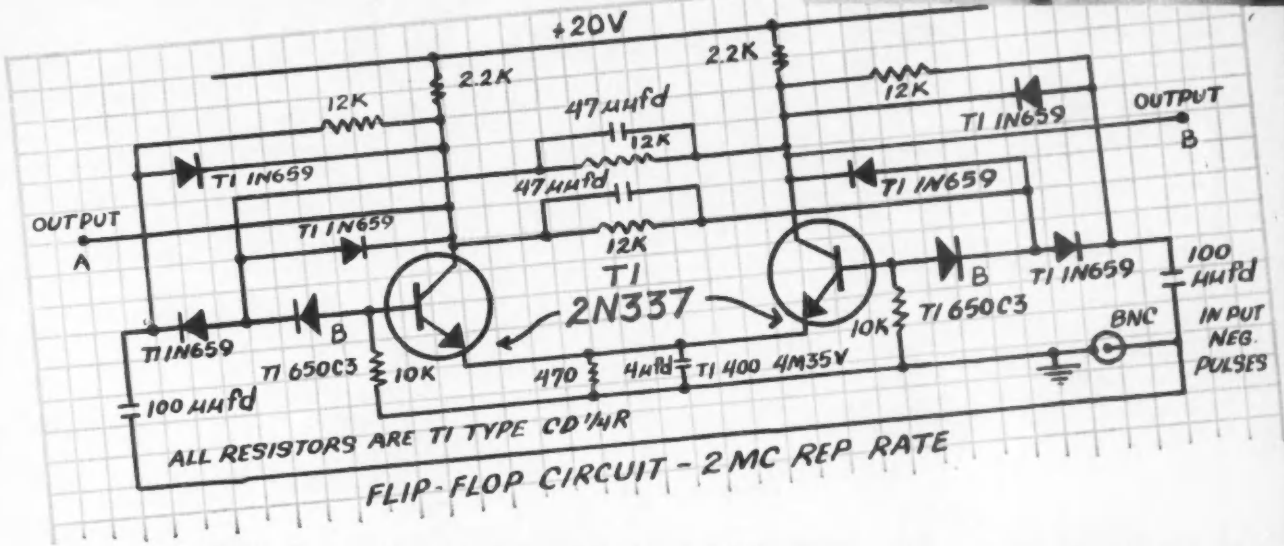
SILICON TRANSISTOR RELIABILITY DATA

Complete parameter analysis of TI 2N332 through 2N343 — a graphic presentation of parameter behavior with time when one type transistor from a series is subjected to stated tests. The graphs above are representative of this data.

These reports are available by writing on your letterhead to your nearest TI sales office, and are not available through magazine reader service cards.

HIGH SPEED SWITCHING





. . . with reliable T/I silicon transistors

New improved TI 2N337 and 2N338 specifications provide greater design flexibility for your switching circuits . . . nuclear counters . . . pre-amplifiers . . . RF amplifiers . . . 455 KC IF amplifiers . . . and many other high frequency applications.

You get high gain at low current levels with TI diffused silicon transistors. High alpha cutoff . . . 10 mc min for 2N337, 20 mc min for 2N338 . . . and extremely low collector capacitance assure optimum performance in your switching and high frequency amplifier applications.

Over four years of mass production and successful use in the most advanced military and industrial applications have proved the value of the TI 2N337 series. Consider TI's guaranteed specs when you select devices for your next transistor circuit. These units are immediately available in production quantities or from large stocks at all authorized TI distributors.

design characteristics at 25° C ambient (except where advanced temperatures are indicated)

		test conditions		2N337 min	2N337 design center	2N337 max	2N338 min	2N338 design center	2N338 max	unit
I_{CBO}	Collector Cutoff Current	V_{CB} = 20V	I_E = 0	—	—	1	—	—	1	μA
	at 150°C	V_{CB} = 20V	I_E = 0	—	—	100	—	—	100	μA
BV_{CBO}	Breakdown Voltage	I_{CB} = 50μA	I_E = 0	45	—	—	45	—	—	V
BV_{EBO}	Breakdown Voltage	I_{EB} = 50μA	I_C = 0	1	—	—	1	—	—	V
h_{ib}	Input Impedance	V_{CB} = 20V	I_E = −1mA	30	50	80	30	50	80	Ohm
h_{ob}	Output Admittance	V_{CB} = 20V	I_E = −1mA	—	0.2	1	—	0.2	1	μmho
h_{rb}	Feedback Voltage Ratio	V_{CB} = 20V	I_E = −1mA	—	200	2000	—	300	2000	X10^{-6}
h_{fb}	Current Transfer Ratio	V_{CB} = 20V	I_E = −1mA	0.95	0.985	—	0.975	0.99	—	—
h_{FE}	DC Beta	V_{CE} = 5V	I_C = 10mA	20	35	55	45	80	150	—
$f_{\alpha b}$	Frequency Cutoff	V_{CB} = 20V	I_E = −1mA	10	20	—	20	30	—	mc
C_{ob}	Collector Capacitance*	V_{CB} = 20V	I_E = −1mA	—	1.2	3	—	1.2	3	μμf
R_{cs}	Saturation Resistance†	I_B ‡	I_C = 10mA	—	75	150	—	75	150	Ohm
h_{fe}	Current Transfer Ratio	V_{CB} = 20V	I_E = −1mA, f = 2.5mc	14	22	—	20	24	—	db
t_r	Rise time§			—	0.05	—	—	0.06	—	μsec
t_s	Storage Time			—	0.02	—	—	0.02	—	μsec
t_f	Fall time			—	0.08	—	—	0.14	—	μsec

* Measured at 1 mc † Common Emitter ‡ I_B = 1mA for 2N337, 0.5mA for 2N338 § Includes delay time (t_d)

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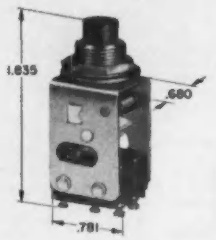
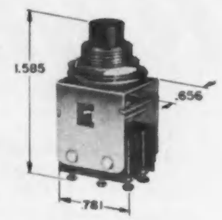
CIRCLE 75 ON READER SERVICE CARD

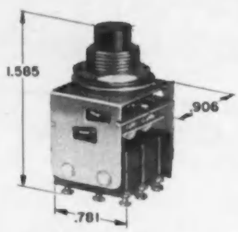
MICRO SWITCH Precision Switches



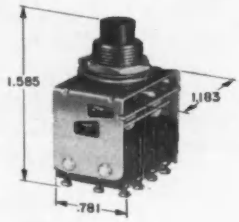
Maintained 2-pole



Momentary 2-pole



Momentary 3-pole



Momentary 4-pole

COMPACT

long-life, snap-action pushbutton switches

The high quality and dependability of these pushbutton switches make them ideal for use in such fields as aircraft, missile guidance, data processing, and office equipment. Features that contribute to excellent performance include:

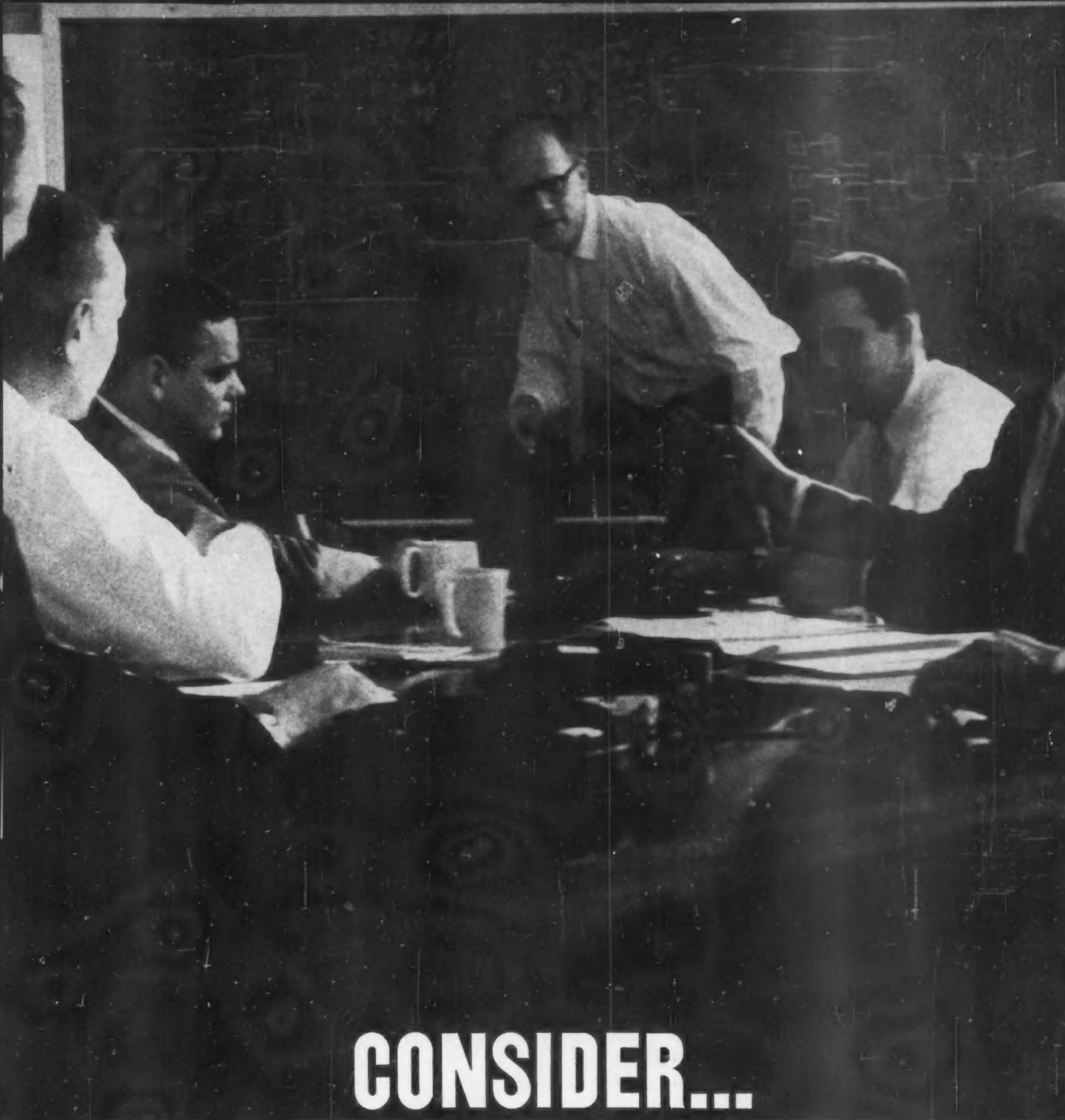
1. Long-life, precision, snap-action basic switches; enclosed contacts prevent fouling by dust and dirt.
2. Choice of momentary or maintained-contact switching functions. Momentary types transfer circuit only while the button is depressed. The maintained type transfers circuit alternately from one position to the other with each push of the button.
3. Actuator on momentary types incorporates a pretravel/overtravel spring and an over-center snap mechanism which provides optimum "feel" of operation and non-tease actuation of all the basic switches.
4. Buttons are of high-strength plastic, have concave surface for optimum finger control.
5. Switch terminals are of double turret design, provide for proper solder connections.
6. These switches are available with buttons in black, white or brilliant red or green.
7. These compact assemblies permit close spacing of buttons on panel, save panel costs and increase operator efficiency.

The complete MICRO SWITCH line of pushbutton switches contains variations to meet almost any requirement. Additional information and application assistance are available from the MICRO SWITCH branch office near you. For more information on the above four types, send for Data Sheet 167.

MICRO SWITCH . . . FREEPORT, ILLINOIS
A division of Honeywell
In Canada: Honeywell Controls Limited, Toronto 17, Ontario

Honeywell
MICRO SWITCH Precision Switches

CIRCLE 77 ON READER SERVICE CARD→



Lockheed for telemetry

Out of Lockheed creative engineering sessions such as this come advanced design and proven performance in the field of telemetry. Lockheed's pioneer work on the X-17 project resulted in the first successful telemetering of vital data during re-entry. Research continues to provide even greater reliability of performance to meet present requirements.

The Lockheed Electronics and Avionics Division (LEAD) is currently conducting research in Frequency Modulated and Pulse Modulated Systems for industrial and military needs.

For proven reliability in telemetry components and systems, consider LEAD.

Look to Lockheed for LEAD*ership in Electronics*

LOCKHEED ELECTRONICS & AVIONICS DIVISION

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is specially engineered for the air conditioning industry

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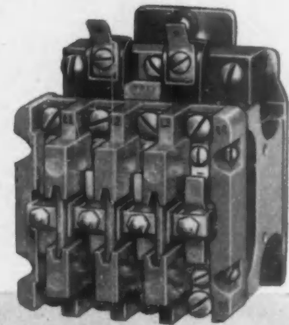
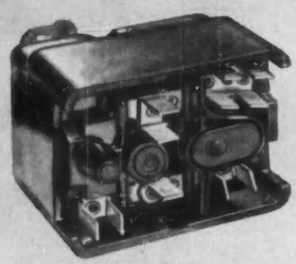
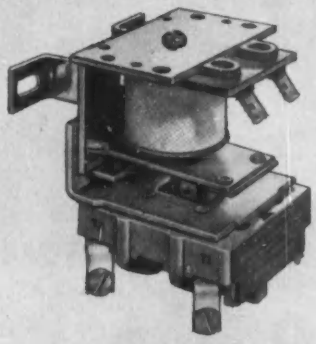
ALL PRICED TO MEET THE NEEDS OF VOLUME USERS



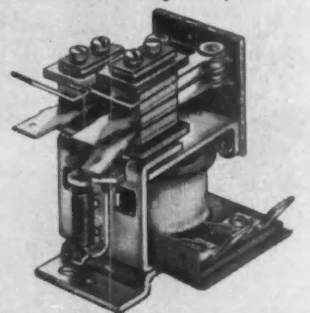
TYPE C—30, 40, 50 AMP. 2-3-4 pole 30 amp.—600 volts. 2-3-4 pole 40 amp.—230 volts. 2 pole 50 amp.—230 volts. Same mounting holes and coils for all ratings and pole forms.



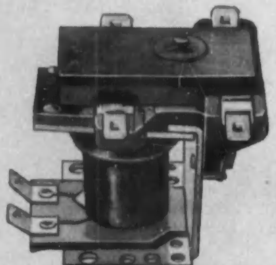
SERIES 128000 POTENTIAL STARTING RELAYS For starting single phase capacitor start compressors.



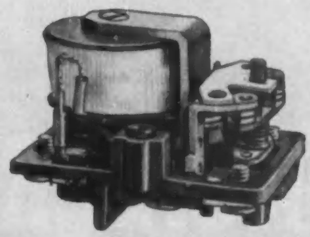
TYPE 80 CONTROLLER Specific design for nominal 3 HP or 3-ton single phase compressors.



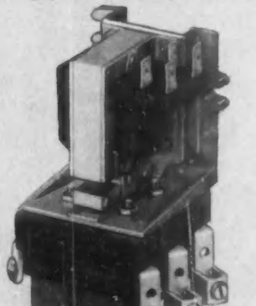
GENERAL PURPOSE RELAY 98000 Series AC or DC. Permits engineering short cuts lowering your "finished product" cost.



TYPE 75 Low cost power relay. Dependably handles up to 6000 W. at 240 V., resistive load per pole. Compressor rating 2 poles, 18 amp. running, 90 amp. locked rotor at 250 volts.



SERIES 129000 SHUNT TYPE RELAY—SPNO, SPNC or NO-NC For standard commercial voltages. Other coils available for special application. For heater, fan control, general circuit switching, etc.



TYPE S—30—40 AMP. Low cost. Small size. Exceed rigid requirements of industry's largest users.

Consult your local RBM Product Application Engineer or Write for Bulletins 1030A, C-8, 1010A, 1060 and C-10.

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RBM Controls Division

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Factories Located at Peru, North Manchester and Logansport, Indiana

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THE FIRST SMALL COMPUTER WITH BIG COMPUTER PERFORMANCE

Program it for
- ANALOG COMPUTING
- SIGNAL GENERATION
- DATA REDUCTION

The Donner 3500 brings all the versatility of big general-purpose analog computers right to your desk or bench. And it's practical for more than computing.

Here's Why: *it's small and portable (23 lbs); precise (0.1%); contains 10 amplifier channels; is reasonably priced ($1200-$1800) and convenient. By repatching, you can use it in the lab as a versatile signal generator, for data reduction or signal conditioning at test sites, and as a general purpose computer in the classroom, field, or at your desk.*

As A Computer—Up to three 3500's can be slaved together, giving big, 30 amplifier computer performance in a small package. Chopper stabilized amplifiers and 0.1% computing components assure high precision over full 100 volt range. A complete line of accessories lets you solve non-linear equations or equations with non-constant coefficients. For teaching, a single 3500 can be used simultaneously by two groups of students without mutual interference. Two detachable problem boards, each controlling half the computer, replace the standard problem board for this purpose.

As A Signal Generator—Re-programming the problem board converts the 3500 to a signal generator, simultaneously forming sine, cosine, square and triangular waveforms of high precision. You can also use the 3500 as a constant current or constant voltage power supply and a low frequency wave analyzer.

For Data Reduction—The 3500's amplifiers are easily programmed at the problem board for signal conditioning or data reduction. By simply removing a few screws, the problem board tilts up for mounting the 3500 in the instrumentation rack. Remote control feature allows data to be controlled at the test site.

Want More Information? *Your nearby Donner engineering representative will be happy to give you complete information on the 3500 and arrange a demonstration. Or you may write Department 0812.*

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With a PACE® *Computer you can* TAKE A REACTOR "CRITICAL"... *simulate <u>any</u> dynamic problem!*

By simulating the action of a nuclear reactor on a PACE Electronic Analog Computer, these engineers are building greater safety and efficiency into tomorrow's larger, more complex systems.

This ability to simulate machine and process performance on PACE Electronic Analog Computers is proving the key to better designs and lower costs in a variety of industries.

Engineers gain new insight into equipment performance. Computers chart graphic pictures of temperature, pressure, speed or any other key factor. As operating conditions are changed from ideal to adverse, engineers can observe the reaction of each variable with complete safety. They can see when and why breakdown occurs.

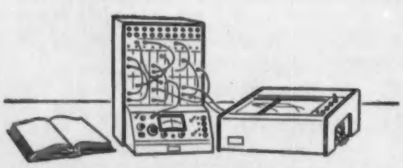
New designs can be tested to destruction while still on paper. As a result, "bugs" can be worked out before prototypes or pilots are built. Computers can be used to study operating equipment for improvement without interrupting normal production. All these advantages mean tremendous reductions in design costs and improved equipment performance.

Electronic Associates, the world's largest manufacturer of general purpose electronic analog computers, offers a complete line of analog computing equipment and accessories. And you'll be surprised to learn how easy this equipment is to operate.

EAI operates three Computation Centers where, for a low rental rate, EAI analog specialists will aid you in finding solutions to your most complex problems. Write for Bulletin **CC-821-K.**

If you would like information on how actual problems were solved with PACE Analog Computers, mention your field of interest and we'll send appropriate literature.

Outstanding career opportunities for engineers with proven ability—résumés invited.



New solid-state computer and desktop X-Y plotter.

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Long Branch, New Jersey

Will the Transistor Boom Static Switching?

The transistor is pumping new life into the field of static switching. Proponents say the new components will erase the most frequently voiced objections to static switching: high cost and large size. One company, Square D, which was originally frigid on static switching devices, says it is readying the biggest promotion campaign in its history to market a new line of transistorized static control. General Electric's Industry Control Dept. also is pushing transistorized static control, now sees a "virtually unlimited market" for them.

High hopes fell

Static switching has had a stormy history. Westinghouse's Cypac system, which performs its circuit logic with magnetic amplifiers, is generally considered the first static switching system. General Electric soon followed with two systems: one was an all-magnetic amplifier system, the other was a combination of static units and relays. Magnetics, Inc. made available a switching reactor, which was a magnetic amplifier device that could perform many of the functions of static switching—AND, OR, NOR, and Memory—with a single unit.

All three sellers started off with high hopes, which were soon dashed. At first the big market was thought to be in machine tool control where repetitive operations wore out relays. But three things killed off this boom before it ever started: 1) static control turned out to cost almost twice as much as conventional relay control; 2) relays, which the static units were to replace, improved spectacularly (at the time, a relay might perform 3,000,000 operations at best; today, new designs operate for 10,000,000 in regular service); and 3) the bottom dropped out of the machine tool market in the recession of 1958.

'59 sales improve

In 1959, sellers of magnetic amplifier static switching systems have fared much better. They've aimed their products at different markets, primarily steel, chemical processing, and materials handling. Static units have turned up in recently installed conveyor control systems, blast furnace controls, and annunciator systems.

Now the big excitement centers on transistorized static control. Says an exuberant GE engineer, "The high speed of transistorized static switching allows us to do a tremendous number of things with a very small piece of hardware–and with no moving parts." Two approaches are being used: transistorized NOR circuits and static switching with conventional transistor circuits.

Square D's plans

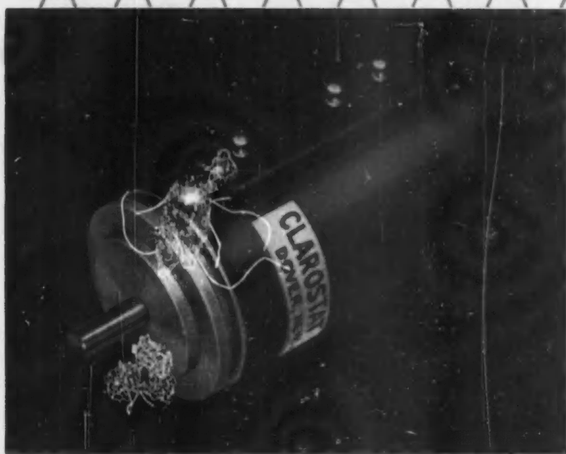
At Square D, Vice President Mitchell Kartalia told CtE that although the company's production is just getting started, a widespread application plan is already in effect. A special field force has been trained to educate the company's regular sales staff and to help with application problems. As for the market, Kartalia says, "Transistorized static switching will become a heavy factor on automatic processing lines, programming, and annunciator systems." With a transistorized system capable of performing 2,500 operations per sec, Square D expects static switching to make substantial inroads into its sales of mechanical relays.

GE's enthusiasm

At GE, application engineers are predicting wide acceptance for the company's Directo-Matic Systems (its new transistorized static control) in automatic warehousing operations–because of transistorized units' high speed of operation and ability to perform many functions; in hot

MULTI-TURN

PRECISION POTENTIOMETERS



Another outstanding advance in potentiometer design by Clarostat *imagineering* . . .

Clarostat Series 55 Multi-Turn Precision Potentiometer *exceeds* all applicable MIL specifications. The new design permits up to 20% greater winding length in a given 10-turn outside diameter. Maximum protection against environmental humidity, salt spray, shock and temperature extremes.

Available in wide range of electrical and mechanical characteristics.

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- **Minimum** runout. **Minimum** end resistance. **Minimum** "noise." **Maximum** stability. **Maximum** resolution.
- Servo and bushing mountings. Panel ball bearing. Oil-impregnated sleeve rear bearing.
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and cold strip mill controls—because of reliability and high speed; in paper, cement, mining, and chemical applications—because of its resistance to corrosive atmospheres; in missile launching, checkout, and inspection systems—because of the reliability and versatility.

Cutler-Hammer's indecision

Another newcomer to the field is Cutler-Hammer, which, after an initial cold shoulder to static controls, produced its first systems with switching reactors made by Magnetics, Inc. Since C-H purchased Airborne Instruments Laboratories, it has been combining its own know-how in industrial control with AIL's experience in electronics. The result: transistorized static switching applied to a data accumulation system for an electrolytic tinning line. Cutler-Hammer, still not sure which way static switching will go, has established a combined group of C-H and AIL people to study and research various forms of switching.

Allis-Chalmers is also watching the new interest in transistorized static switching. The company, which brought out a static relay for switchgear, is not yet ready to enter the field, though the company's belief in the future of static control is strengthening. For the present, A-C is using Magnetics, Inc. switching reactors in static control applications.

Erie Resistor, a relative newcomer to the field, is now offering both transistorized NOR static switching and static control with conventional transistor circuitry.

What about machine tools?

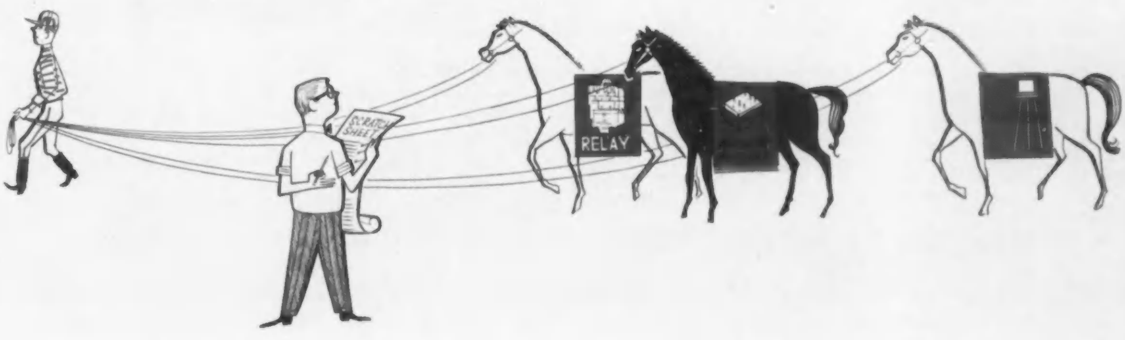
Probably the biggest question still unanswered about transistorized static switching is will it ever be applied on a widespread basis to machine tool control? The answer seems to be *eventually*. Even at GE's relay-oriented Specialty Control Dept., engineers say "transistorized static control for machine tools is coming, but we wouldn't want to say when."

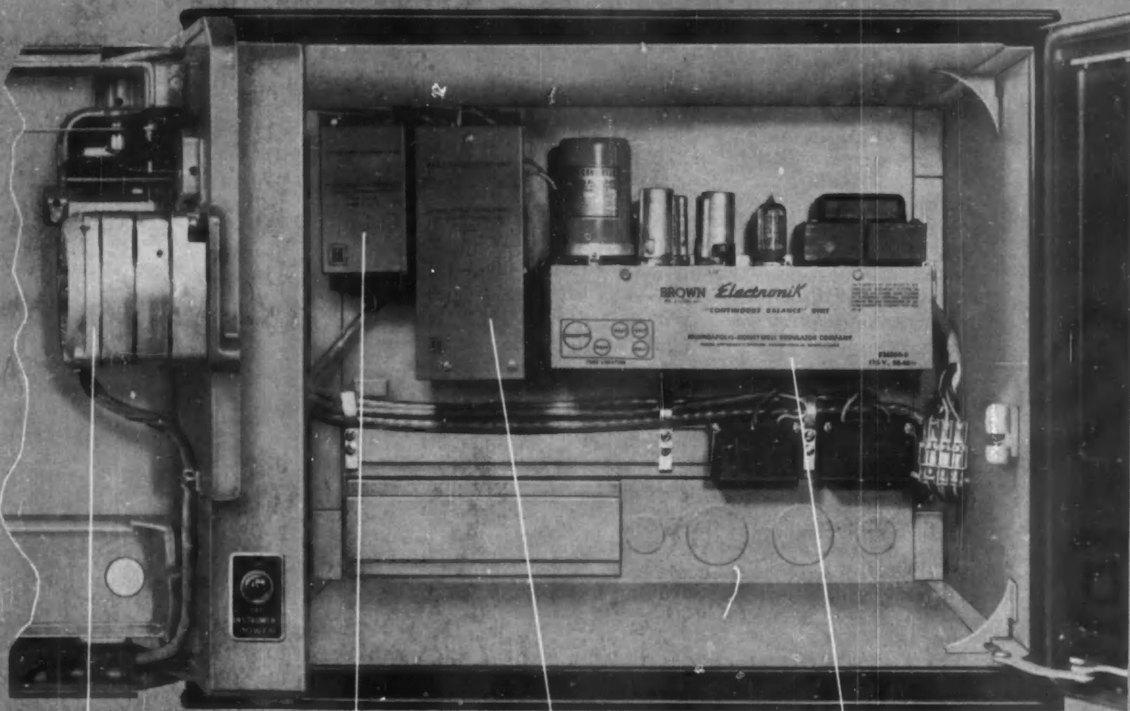
A little more positive evidence will be unveiled in 1960 when the National Machine Tool Builders Association holds its once-every-five-year show. One control specialist from Milwaukee predicts "Most exhibitors at the National Machine Tool Show will exhibit control devices using static switches." Indications are that Allen Bradley, one of the kingpins of the mechanical relay business, will offer some form of static control by show time.

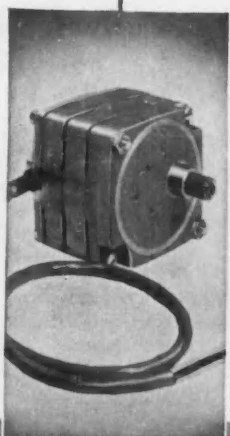
Some caution

Not everybody, of course, is sold on transistorized static switching. One engineer pointed out some possible dangers. First off, he says, the transistorized circuitry is likely to be more complicated, might possibly prove too complex for machine tool design engineers as well as shop maintenance men. "Machine tool people", he added, "object to having all those wires crammed together in a small space when as many as 20 NOR units are wired up into a package. And what do you do if one of them burns out?—replace them all?"

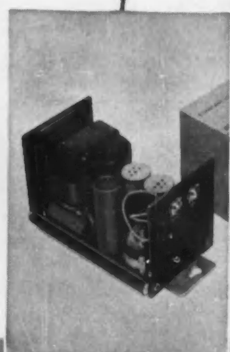
Westinghouse, the pioneer, agrees. It's using transistorized NOR circuits in steel mill programmers which it is engineering. But the company claims the transistor NOR requires too complex engineering for most customers, has refused to sell its NOR logic as a component. Westinghouse is sticking with magnetic amplifier static switches, which the company says are finally selling very well.



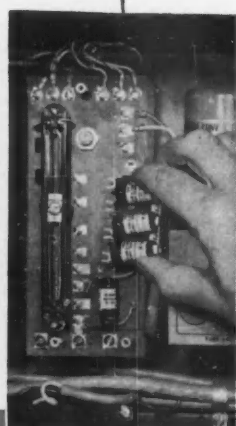




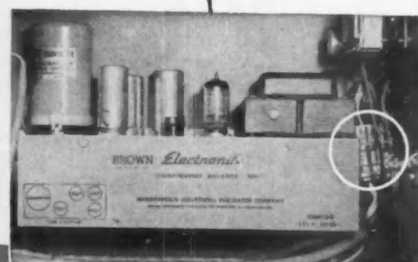
Servo Motor has sectional housing, leakproof oil wick, printed circuits for simplified servicing. Any major part can be replaced in 2 minutes.



Constant Voltage Module—Uses Zener diodes and an ambient temperature compensator to replace standardizing mechanism.



Measuring Circuit Module—Contains easily-changed range spool panels and vernier adjustment. Range is changed simply by replacing screw-clip panels of fixed resistors.



Amplifier Module—Quick-connect design permits fast, easy removal for servicing and replacement. Circle shows quick connect plug.

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New modular design...

makes *ElectroniK* potentiometers easier to use and maintain

Now, four great new features add new operating and servicing ease to all *ElectroniK* circular and strip chart potentiometers.

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- **A new constant voltage unit replaces batteries, standard cells and standardizing mechanisms.**
- **A new measuring circuit, with quick-change range spools, simplifies range changing and reduces stray pickup.**
- **A quick-connect feature lets you remove the amplifier for service and replace it quickly.**

Now, modular design is combined with the traditional precision of *ElectroniK* potentiometers, to give you a greater value than ever in accurate, dependable measurement and control.

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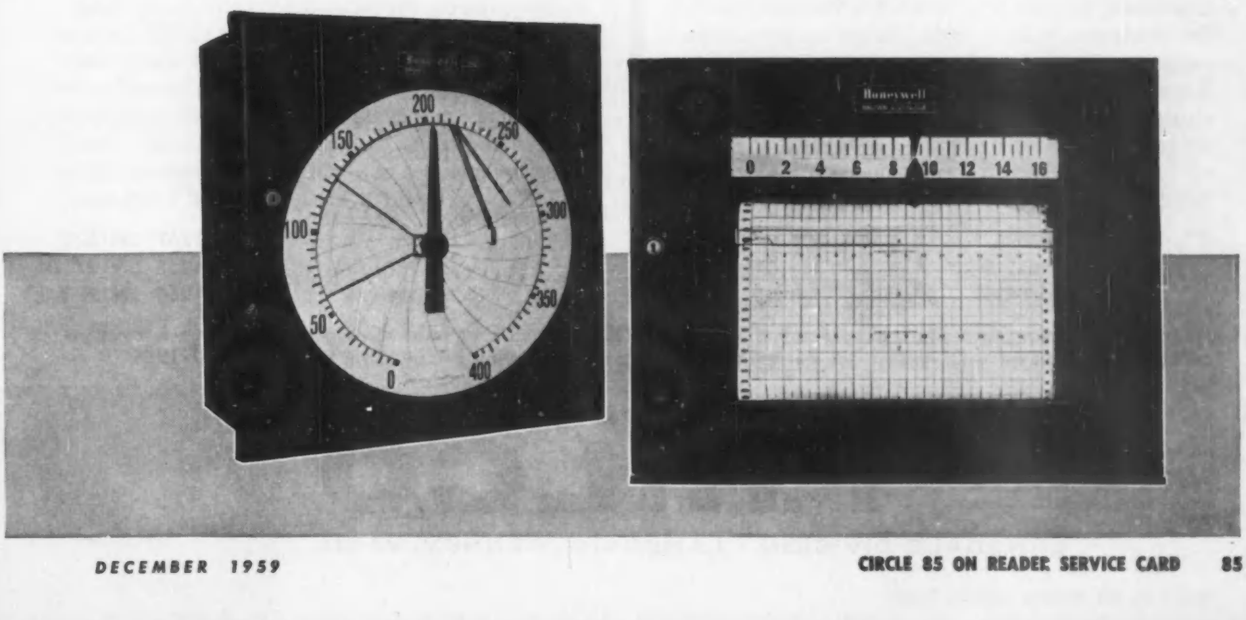

... High Speed Switches

Philco's full range of silicon high speed switching transistors, in both PNP and NPN types, provides the designer with a wide choice to meet the requirements of all high temperature applications. They are engineered and specified to permit simple, straightforward design of practical circuits up to 5 mc pulse rates, using saturated configurations and up to 30 mc pulse rates with non-saturating techniques. Packaged in TO-1, TO-5 and TO-9 cases.

PNP 2N496, 2N1119, 2N1429 **NPN** 2N1199

... High Frequency Amplifiers

Philco amplifying transistors are available in nine types, covering the complete high frequency range. The designer will find both PNP and NPN types that permit the design of communications systems at frequencies up to 60 mc. They have low collector capacitance and are available with restricted beta ranges to simplify design problems. All offer excellent performance at junction temperatures up to +140°C. Packaged in TO-1, TO-5 and TO-9 cases.

PNP 2N495, 2N1118, 2N1428 **NPN** 2N1267, 2N1268, 2N1269, 2N1270, 2N1271, 2N1272

***All types environmentally tested in accordance with MIL-T-19500A ... and have been thoroughly field-proven in countless critical military and industrial applications.* For complete data and application information, write Dept. CE-1259**

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CIRCLE 86 ON READER SERVICE CARD

Control
ENGINEERING
DECEMBER 1959

You're in the Battle, Too

In mid-summer the chief instrument engineer of a company that designs and constructs petroleum refineries observed that the most powerful deterrent to acceptance of improved automatic systems would be labor's footdragging. This represented a marked shift from economic justification, which bedeviled him in 1958-59, and the lack of management's understanding of what automatic systems were capable, which slowed him in the earlier five years. Through necessity he had developed ability at teaching the ideas and benefits of instrumentation and control. Then he had become proficient in the economics of control. Would he now have to participate in labor questions? Wasn't it sufficient that he could solve control problems, interpret their solutions, and translate them to dollar earnings?

We recalled his observation when the Taft-Hartley injunction in the basic steel industry was taken to the courts. At that time a series of interviews with technical management people responsible for instrumentation and control in the basic steel industry confirmed his observation. After coming to within one cent per hour on wages, the industry-union dispute had concentrated on the real long-range issue—work rules. While they knew that the wording of the defunct steel contracts did "not prevent or interfere with adjustments that result from technological changes, changes in equipment, or manufacturing processes",* the men interviewed believed that technological improvements would become the critical factor in the work rules of new contracts. Their beliefs were founded on knowledge that steel management would apply every practical means of making its plants continuously produce uniform quality product just as automatically as possible.

Your inclination is to leave the worrying entirely to management and the unions, to forget it when new steel contracts are written. Unfortunately, you can't—for two good reasons. First, from "now through most of 1960, there will be a string of . . . bargains to be struck in steel, aluminum, railroads, canning, aircraft, paper, machinery, and electrical products."* Many of these industries face an extra hurdle because their existing contracts are not as lenient toward technological changes as even the old steel contracts. Second, all of these industries plan increases in expenditures on instrumentation and control in 1960 (the increases over 1959 range from 5 to 15 percent). For you, whether employed by a user or a maker, to carry out the plans, the thorny bargaining issue over applying technological changes must be resolved. It is a vital question you should thoroughly understand. Once familiar with it, you will see that steel management, fighting the management battle for all industries, has also been fighting your battle.

W. E. Vannah

* *Business Week*, October 24, 1959.

DIGITAL VOLTMETER, $825

Automatic range and polarity selection. Just apply the probe and read voltage directly!

hp 405AR DC DIGITAL VOLTMETER is a completely new instrument providing, literally, "touch-and-read" voltage measurements between 1 and 1,000 volts. *Range, even polarity, are automatically selected.* Readout is in-line, in bright, steady numerals. *New, novel circuitry provides a stability of readings virtually eliminating jitter in the last digit. This reduces operator fatigue and avoids uncertainty.*

Special features include a floating input, electronic analog-to-digital conversion, digital recorder output and front-panel "hold" control permitting manual positioning of decimal. Voltage sampling rate is variable from 1 reading every 5 seconds to 5 per second; or can be controlled externally by a 20 v positive pulse.

BRIEF SPECIFICATIONS

Range: 0.001 to 999 v dc; 4 ranges.
Presentation: 3 significant figures, polarity indicator
Accuracy: ±0.2% of reading ± 1 count
Ranging time: 1/6 sec to 2 sec
Input impedance: 11 megohms to dc, all ranges
Response time: Less than 1 sec
AC rejection: 3 db at 0.7 cps; min. 50 db at 60 cps
Price: $825.00

Data subject to change without notice. Price f.o.b. factory.

hp

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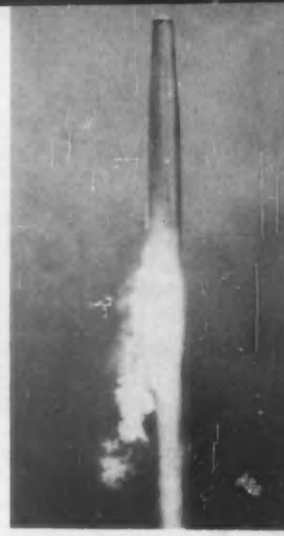
CABLE "HEWPACK" • DAVENPORT 5-4451
FIELD REPRESENTATIVES IN ALL PRINCIPAL AREAS

FIG. 1. First THOR squadron launches a missile during training at Vandenberg Air Force Base.



At tactical launch sites the same system of sequence timers that controls the countdown will exercise the IRBM on a regular schedule. The philosophy: prevent malfunctions rather than correct them.

How They Keep Thor Operational

LEWIS H. YOUNG
Control Engineering

In the operational THOR squadron, on guard 24 hours a day against enemy attack, the key function of the men and ground support equipment is to keep the missile ready to go, to prevent malfunctions rather than correct them. To do this, the squadron has the use of several trailers loaded with automatic and semiautomatic checkout equipment, so much that almost 85 cents out of every dollar spent for THOR missiles buys ground support equipment.

Four objectives sum up the philosophy behind the THOR operational alert:

1. Minimize the number of people required to launch the missile and to maintain it.
2. Reduce the time for launching to as close to zero as possible.
3. Minimize the human error possible in the launching system by replacing human operators with automatic sequencing equipment. At the same time, reduce the skill level required by the handful of launching and maintenance personnel.
4. Systematize the launching and maintenance procedure so that it can be followed easily by the troops.

Under today's battle order, a typical THOR squadron is armed with 15 ready-to-fire missiles which are organized into five positions, three launch emplacements to a position. The *position* becomes the elemental combat unit, just as a squad is the elemental unit in an infantry company and a flight in an Air Force squadron.

With the deployment of missiles, new categories of equipment have worked their way into military jargon. There is heavy instrumentation and control at all three levels: squadron, position, and emplacement. Each squadron headquarters has a RIM building (receiving, inspection, and maintenance), two SCOTs (supplementary checkout trailer) and two MCOTs (missile checkout trailer). Each position commander has an LCT (launch control trailer), an MCOT, and its own power generation and distribution system (no initials assigned). At each emplacement, the IRBM is surrounded by an EET (electrical equipment trailer), an HPT (hydraulic-pneumatic trailer), and tanks of RP-I missile fuel and liquid oxygen.

Because the THOR missile system is a sophisticated one, the checkout equipment is sophisticated too, with many different jobs to do. It has to perform electronic

checkout, mechanical checkout, and hydraulic and pneumatic checkout. Some checks are made daily, some weekly, and others monthly. Still other parameters are monitored 24 hours a day. Some inspection techniques involve continuous monitoring at the launching pad; some exercise and countdown the missile at the emplacement; the rest perform systems trouble shooting and maintenance at the RIM building.

Checkout and maintenance

When a missile arrives at the squadron, its first stopping place is the RIM building where it is put through a complete checkout. Two trailers full of equipment, the MCOT and the SCOT, simulate the countdown procedure. With this simulation equipment, the missile goes through a countdown exactly as if it were on the pad, ready to be launched. Only fueling with actual propellants is omitted.

The RIM building checkout is a demanding one. Equipment in the SCOT trailer checks all power supplies, simulates the pressures for checking the hydropneumatic systems. Equipment in the MCOT checks out all functions of the propulsion, guidance, and autopilot subsystems. If the missile passes all tests, it is assigned to an emplacement, attached to the launcher, and covered with a weather-proof shelter.

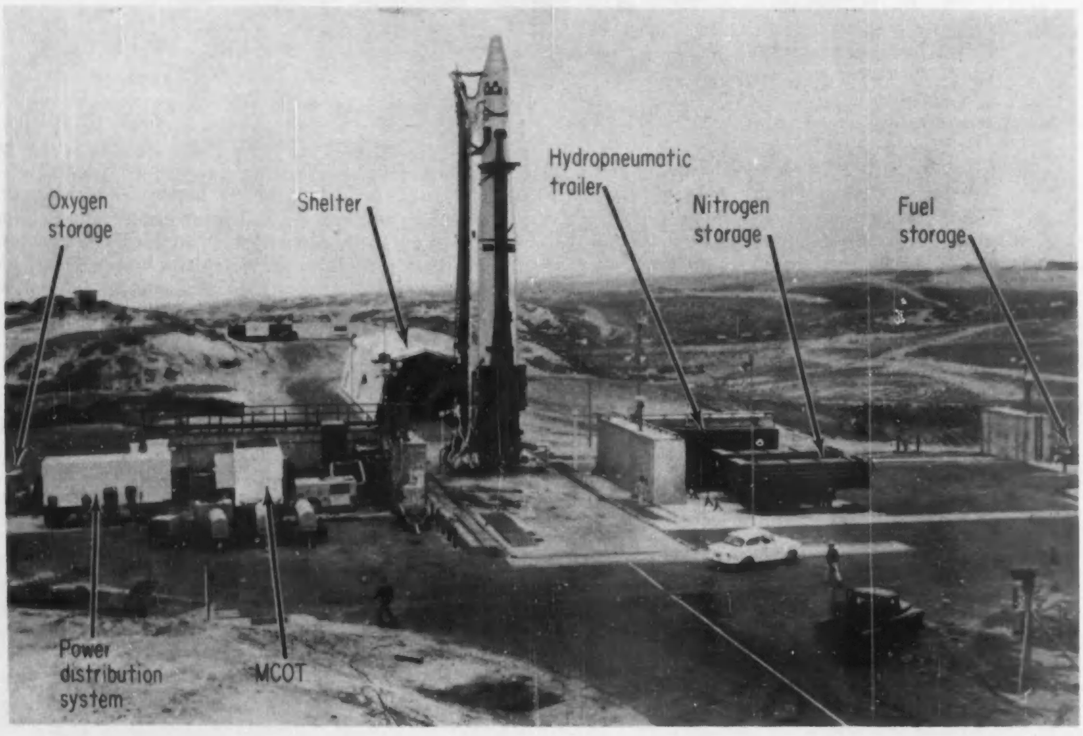
Next step is another intensive inspection, this one conducted at the launching pad. The MCOT programs checkout of the rocket engine, the propellant transfer system, the guidance and control system, the hydraulic system, and the electrical system. At this inspection the missile goes through actual launching procedures, right up to, but short of, ignition of the engines. It is erected, fueled and its guidance and autopilot system aligned. When it passes this test, the missile joins the ranks of weapons in the ready condition.

Focal point of the maintenance program then shifts to the launch control trailer. In the LCT one officer commands the three-missile position, and one enlisted specialist monitors each missile. Only two men are needed to actually launch a missile: the officer and this enlisted specialist.

The LCT is manned 24 hours a day, and some variables are monitored 24 hours a day. The temperature of the chamber in which the guidance system is located is maintained at a constant level; a simple automatic system supplies heating and cooling as conditions warrant. Other heaters keep the fluid in the floated gyros of the inertial guidance system (CtE, October '59, p. 85) at the proper viscosity. The heaters are monitored continuously; a warning light appears if they fail to operate. Temperatures of the propellant system manifolds are measured and recorded so that, if an alert is sounded, the fuel loading computer can compensate for temperature. In addition to these temperatures, one variable in the highly classified warhead is continually watched.

Missile readiness is more difficult to assure than aircraft or artillery readiness. At an operational position, the THOR is *never fired except in anger*. Even to make a training launch, the crew must journey to one of the U. S. missile test ranges. The Air Force will achieve readiness by putting the missile through its paces—short of actual firing—on a regular schedule. The procedure is called exercising. In the readiness program the actual countdown is followed; it is stopped at different stages and different times. For example, countdown, which is divided into five phases, might proceed through Phase I every day. It might be carried through some point in Phase III on a weekly basis. A complete countdown, up to the ignition of the engines, might be carried out only once a month. The actual schedule will

FIG. 2. View of operational launching site at Vandenberg Air Force Base.



vary at the discretion of the command. In addition, unscheduled countdowns are called unexpectedly to train the crews on a tactical basis as well as to serve as additional checks on the readiness of the missile.

The checkout equipment for each subsystem was built by the contractor-supplier of that equipment. Prime contractor Douglas Aircraft then integrated the test gear. All the controls and the monitoring indications are in the LCT. Most of the actual circuitry for launching is contained in the electrical equipment trailer which stays close to the missile.

At Douglas, a spokesman who supervised the integration of much of THOR's checkout equipment says the countdown is fully automatic if everything goes according to schedule. He says, "It is like turning the key on your car." And that makes a good analogy; because the position officer turns a key to start the countdown procedure.

An interesting part of the safety precautions in the countdown revolves around a second key, which has been called by a variety of names: military men prefer the name "Peace-War Switch". It is used because, as already mentioned, a THOR is never fired at an operational base except in anger. The Peace-War Switch controls a circuit that prevents the inadvertent launching of the THOR missile. Unless the key has been inserted and turned to the "War" position, the missile cannot be launched.

Automatic countdown

The countdown procedure is diagrammed starting this page and continuing on pages 92 and 93. Because THOR was the first long range missile to be operational and its time schedule was extremely tight, Douglas proposed a time-sequenced, automatic system. One step in the countdown triggers another. Under such a design, of course, a step cannot proceed until the previous one has been completed successfully. Throughout the procedure there are checkpoints based on time. If after it has started, the countdown has not progressed to a checkpoint by a limiting time, a hold is applied. Other circuits are designed so that if the countdown runs behind the slowest permissable schedule, it is automatically recycled back to an earlier point. If trouble develops, the countdown may be stopped at that point or the hold delayed until the phase has ended, depending on the portion in which the malfunction occurs.

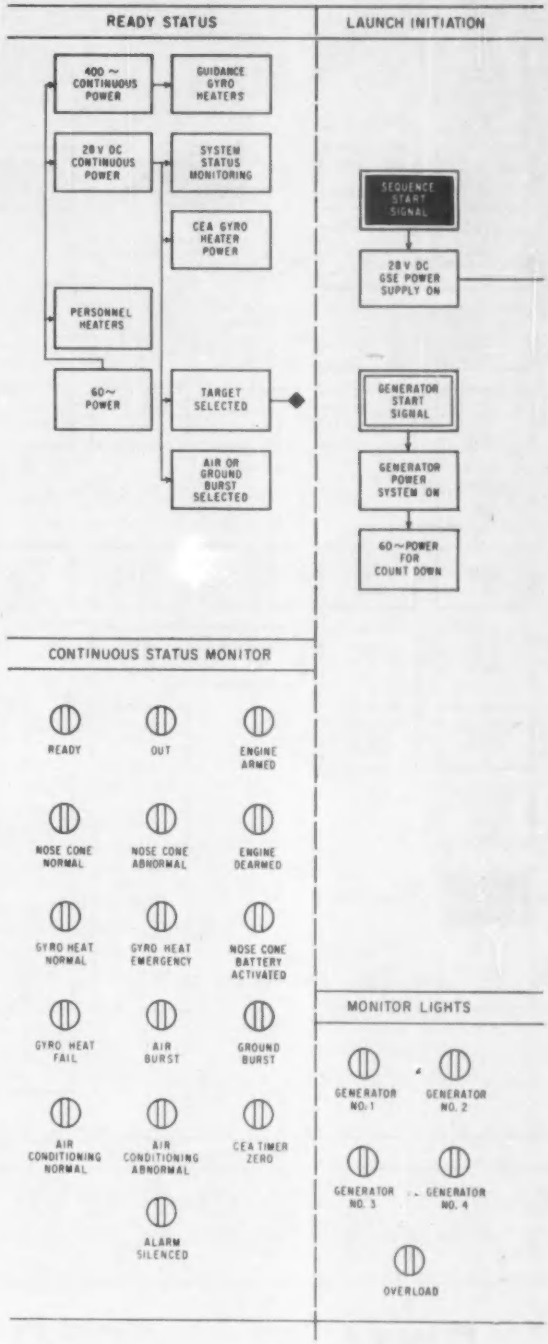
During the countdown—which takes less than 15 minutes from the time the key is turned until the engines are ignited (if need be)—the guidance system is programmed for flight, the shelter moved away, the missile erected and fueled, subsystems checked on external and internal power, and the missile launched.

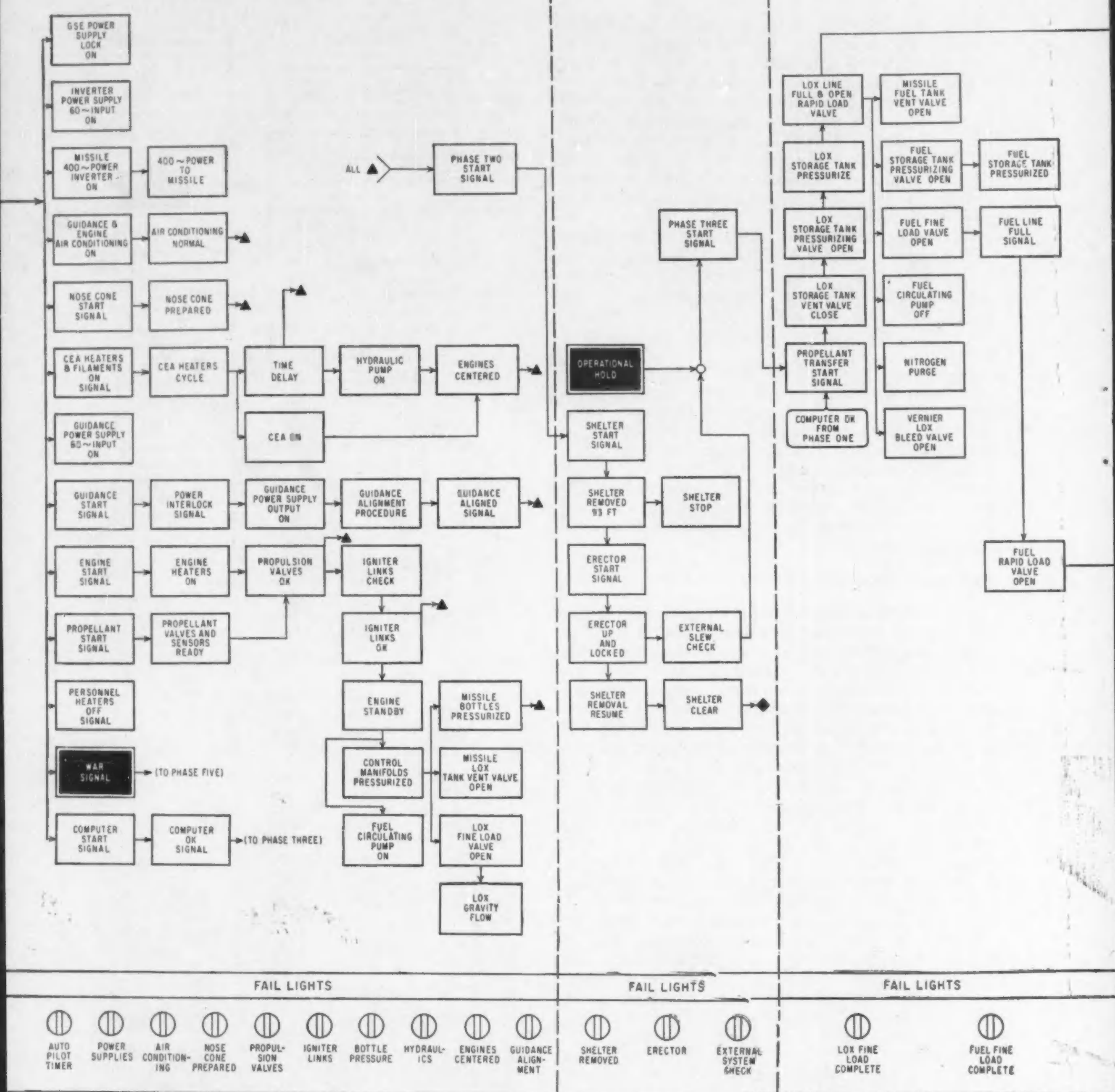
Inside the LCT, the officer and the enlisted specialists watch three panels: the launch control officers' panel, the launch control panel, and the weapons subsystem panel. Heart of the countdown equipment is contained in two chassis in the electronic equipment trailer: one called the monitor system control chassis and the other, the power control system relay chassis.

From the panels, the Air Force crew can tell at a glance the condition of each missile, what phase of countdown is in effect, whether the countdown is proceeding normally or not. If there is a malfunction, a panel light indicates the subsystem in which the trouble

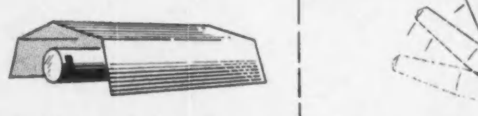
(Text continued on page 94)

THOR ON ALERT



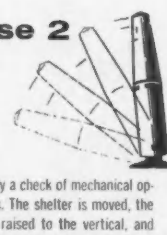


Phase 1



Conducted on external power. It is primarily an electrical check, tests missile's readiness to proceed in the countdown. Initiation of the phase starts missile's 60 cycle and 400 cycle power; turns on engine and guidance system air conditioning; checks nose cone status; warms heaters in control electronics assembly (the autopilot); starts inertial guidance alignment procedure; checks status of engine and propellant valves, and starts the propellant computer. Triangles indicate completion signals required to start phase II — eight are necessary.

Phase 2

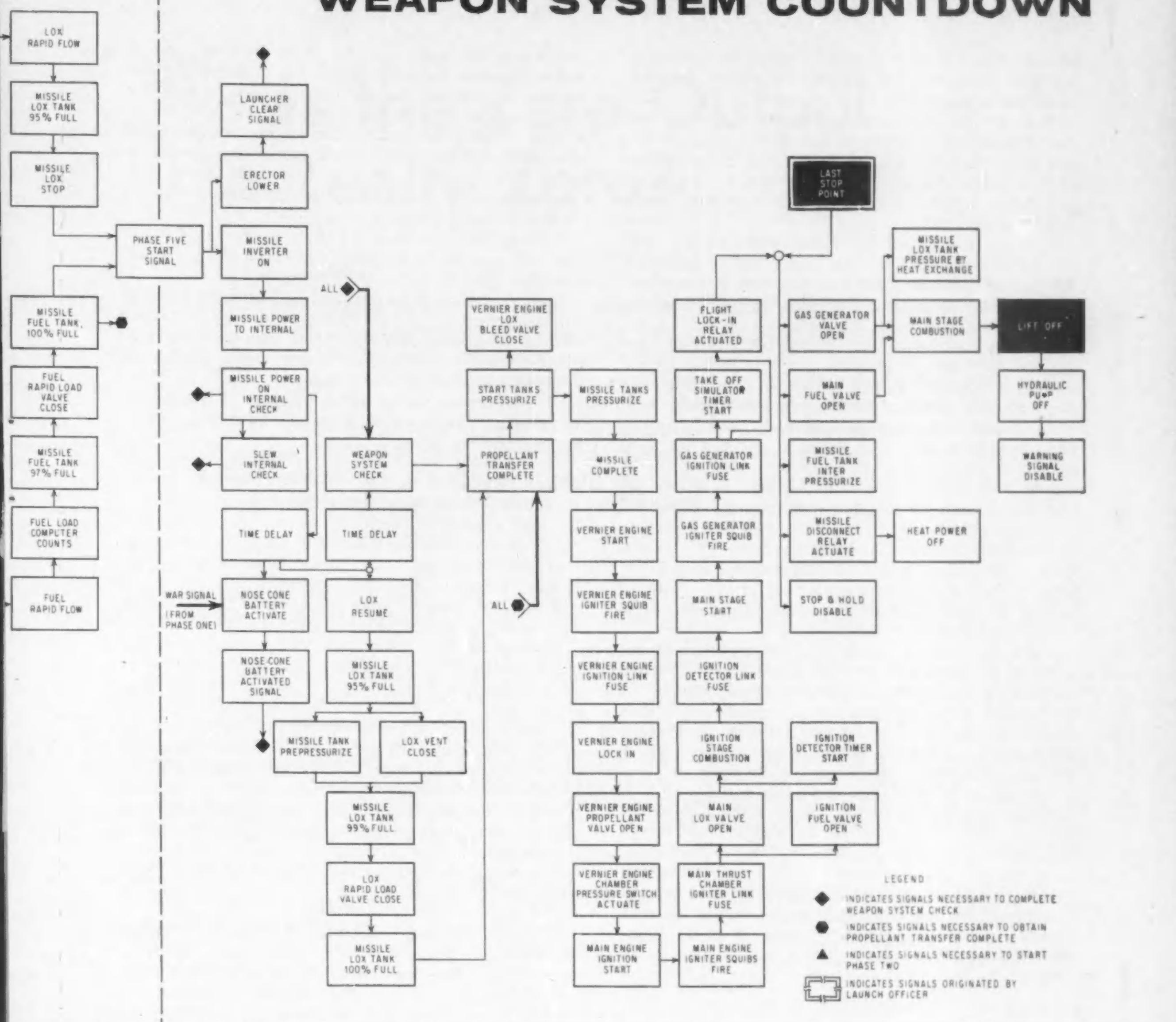


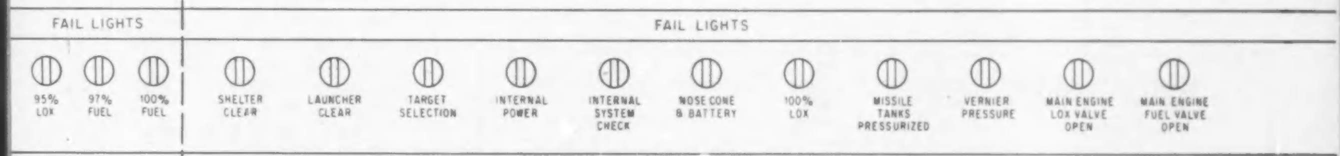
Primarily a check of mechanical operations. The shelter is moved, the missile raised to the vertical, and the engine slewed for centering. A manual hold can be applied if the shelter does not move or the missile does not rise. Completion of slewing initiates the next phase.

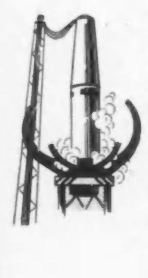
Phase 3

Programs the start of propellant loading. First liquid oxygen lines are filled, then fuel lines are filled. When rapid load valves open, countdown moves into the next phase, which completes fueling.

WEAPON SYSTEM COUNTDOWN







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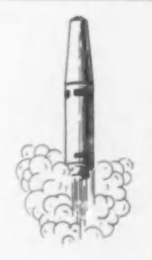
Phase 4

Continuation of propellant loading. Missile fuel tank is filled and liquid oxygen tanks carried to 95 percent of capacity. Completion of fueling, after actual load is computed, starts the last phase.

Phase 5

Final check on internal power. In addition, oxygen loading is completed. If the authenticating signal is not on, countdown stops at the completion of oxygen loading. If authenticating signal has been turned on, missile is pressurized, the engines ignited, and THOR rockets off the launching pad.



has occurred. On another panel, time of the countdown and how much time has elapsed in the particular phase underway is maintained.

Most of the commands which start the different operations of the countdown are directed into the system from the power control system relay chassis by way of the control chassis of the subsystem to be checked out. Some commands move directly from one control chassis to the next.

The first column of the countdown diagram (page 91) lists the variables that are monitored continuously. The power generators may or may not be on at the start of the countdown. Normally they are supplying power, if not, they must be started.

In most countdowns the first step consists of turning the start key which turns on the 28-vdc ground support equipment power. Phase I is an automatic check to determine that the weapon is ready to proceed in the countdown. It is performed on external power. Here is what happens: all wiring is checked for short circuits to see if it is ready to perform electrically; the engine is checked to see if it is ready for firing; the payload is examined to see if it is ready for flight; the guidance system is aligned and readied for flight; the propellant transfer system is checked and set ready to perform. The latter is unique in that it moves large quantities of fuel and liquid oxygen very rapidly—without pumps. Pressure, supplied by gaseous nitrogen transfers all the propellants.

From the chart, it can be seen that eight operations must signal completion to start Phase II. The second stage of the countdown is concerned with moving the shelter and raising the missile to the vertical. A THOR missile, on the alert, lies horizontally in its weatherproof shelter. After the missile moves to the vertical, the engine receives a slew command to center it.

An indication that the shelter is entirely clear is necessary to complete the last phase of the countdown, but only the completion of the engine slew test is required to start Phase III. This part of the countdown starts the propellant transfer.

Figure 3 describes in detail how propellant transfer is started. The system depends predominantly on relay circuitry. To start propellant transfer, three first-phase operations and one second-phase operation have to be completed. Alignment of the inertial guidance system, indication that nose cone has been prepared, and an external system check—all in the first phase—each closes a relay in a series circuit. Erection and locking the shelter—in the second phase—also close a relay in the circuit. Then a check of the fuel loading computer and the pressurization of the missile bottle close two more relays thus completing the circuit from the 28-volt supply to the coil of another relay that operates an actuator to start propellant transfer.

Fueling begins with a fine flow to fill the transfer line and provide an accurate base for loading. Simultaneously, the system is checked for leaks.

When both liquid oxygen and fuel lines are full and rapid flow valves ready to operate, Phase IV is started. During this, propellant transfer is completed. A computer determines the amount of fuel loaded—based on mission, temperature, and density of the fuel. Then the liquid oxygen tank is filled. As soon as the missile fuel tank has the computed load and liquid oxygen stops flowing, the last phase is started.

In the last phase, many of the checks already performed in Phase I are repeated, but on internal power. In addition, such questions as these are answered: Is the right amount of propellant aboard? Are mechanical activities completed (movement of the shelter and erection of the launcher)? Are missile tanks properly pressurized? Is the missile aimed correctly?

Before the missile tanks are pressurized, all signals started earlier and carried over must be completed.

Throughout the countdown, the automatic equipment incorporates time delays to allow problems to solve themselves if possible. If a valve is slow opening, for example, the countdown equipment waits a set period for correction before sounding an alert alarm.

Kept in a ready state by continuous monitoring and regular exercise, the countdown should proceed without a hitch. But what happens if trouble develops? As soon as it does, the countdown is stopped. A light pinpointing the subsystem causing the trouble glows red on the launch control panel. The launch control officer then has to decide whether the difficulty can be resolved by going back in the countdown, by doing something in the LCT, or by trouble shooting.

If trouble shooting is called for, the MCOT programs an analysis to help locate the malfunction. Effort is directed at finding and replacing the black box causing the trouble. If necessary the missile is lowered and taken back to the RIM building. In the RIM building, black boxes can be analyzed to determine the specific malfunction.

During drills at Vandenberg Air Force Base, where the first Thor squadron is training, the chief cause of holds has been found to be external: human errors. Most frequent oversights are the failure to adjust a regulator or the failure to insert an electrical connector properly. Such deficiencies are expected to disappear as training progresses.

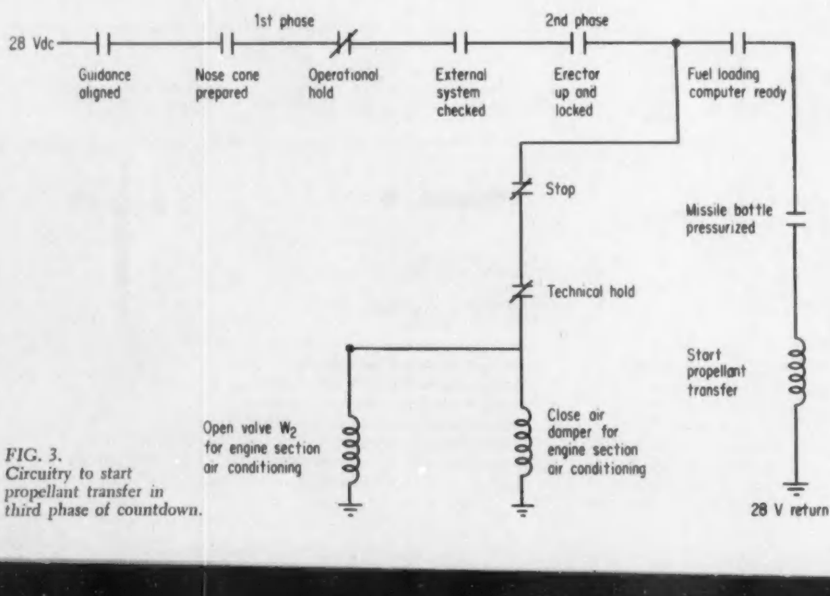


FIG. 3. Circuitry to start propellant transfer in third phase of countdown.

Is the Zero Output Really Zero?

THE GIST: A serious problem confronting instrument users and makers is reaching a clear and mutual agreement on allowable instrument errors. Such an agreement requires defining three major types of instrument uncertainties, understanding how uncertainties result from environmental and design conditions, and specifying the magnitude of allowable errors and preferred test procedures. In this first of two articles, author Entin discusses the general aspects of instrument uncertainties and then elaborates on one major type, uncertainties of zero. The second article will detail uncertainties of scale factor and instantaneous slope, which are related to specifying linearity, tolerance, excitation, and resolution.

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Instrument accuracy requirements are usually expressed by the permissible inaccuracies or, as they will be designated here, by instrument uncertainties. The successful creation of an uncertainty specification implies that:

- the nominal, or ideal, performance characteristic is well established;
- the nature and magnitude of all possible environmental and inherent design conditions which can cause departure from the nominal are known;
- the permissible magnitudes of the total (or individually considered or specially combined) uncertainties which environmental and design conditions produce are well established.

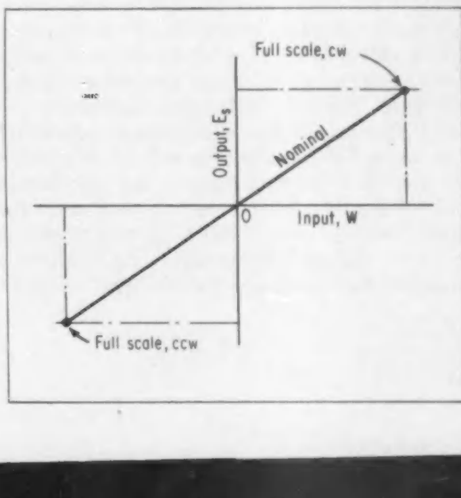
A situation which satisfies all these requirements is hypothetical. Quite frequently instrument specifications must be written without knowing the actual conditions to which the device may be subjected. For example, gyros must be specified for aircraft which have not yet flown, so the best estimates of many conditions must initially suffice. What is important, however, is a continual awareness of all potential sources of instrument uncertainty so as to prevent omission of some critical item or inclusion of an ambiguous one in a specification.

The first step in creating an uncertainty specification is the designation of the nominal characteristic. The nominal can be defined as that output characteristic which the user knows will provide the best operation of his entire control system, without regard to the actual capabilities of the instrument being specified. The heavy line in Figure 1 represents the nominal static output characteristic for a linear instrument. The characteristic has the following properties:

- it passes through the zero input-output point;
- it is perfectly symmetrical about the origin;
- it is a straight line with slope E_S/W most favorable to the user;
- the instantaneous slope at any point equals the average slope, and there are no discontinuities;
- at any given input, irrespective of direction (increasing or decreasing) from which the input is approached, there is a single, unambiguous, repeatable output;
- for dc instruments the line represents the dc output, for ac instruments only the fundamental in-phase E_S component is under consideration.

Once the nominal characteristic is established, the next step is to determine the permissible departures, the uncertainties, from the nominal. Uncertainties fall into three major categories, such as demonstrated

FIG. 1. The ideal input-output characteristic of a linear instrument. Even a straight line like this has important properties.



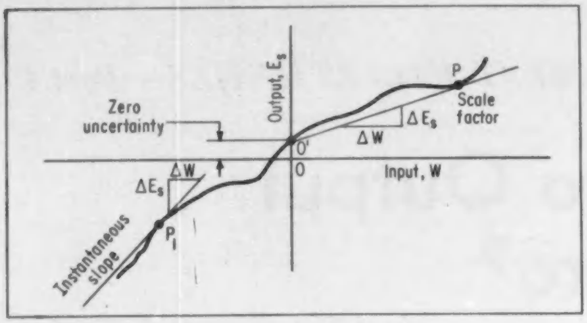
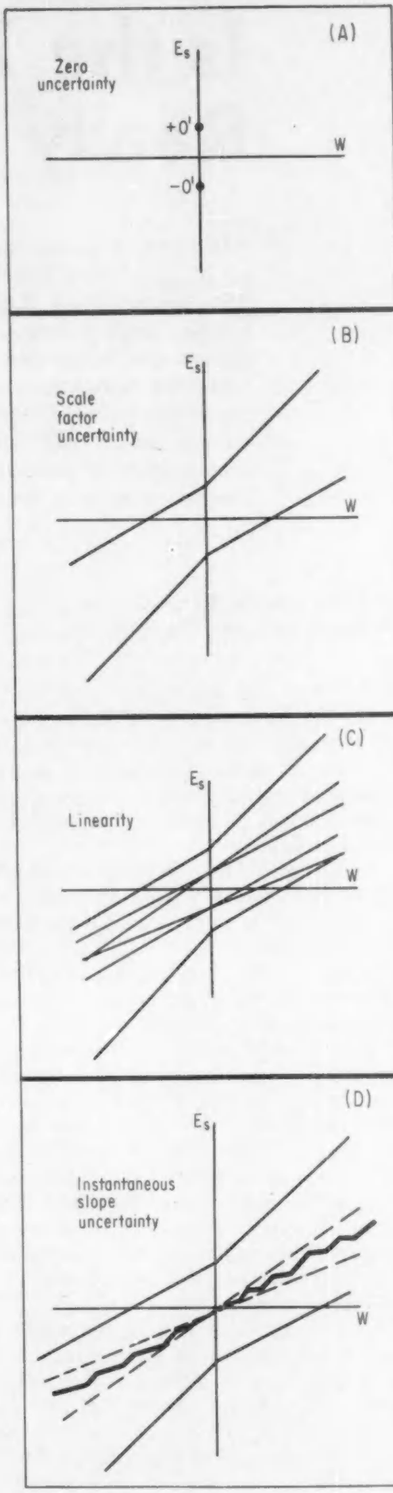


FIG. 2. Typical input-output characteristic, showing uncertainties of zero, scale factor, and instantaneous slope.

FIG. 3. The allowable deviations from nominal are limited by the major types of uncertainties.



by the instantaneous static output characteristic an ac rate gyro might exhibit, Figure 2.

Uncertainty of zero—at zero input, the output is not zero. This specification establishes the points 0 and 0′ within which the output must fall with zero input, as shown in Figure 3A.

Uncertainty of scale factor—a straight line (average slope) drawn through the zero output point and any point on the actual output curve differs from nominal, Figure 2. This specification establishes the limiting overall bounds, using the zero uncertainty as a base value, within which the output must fall at any input level. Within the broad limits imposed by zero and scale factor uncertainties, a linearity specification establishes the width of a narrower band which can be randomly placed as far as zero and slope are concerned but which restricts the output to adherence to a relatively straight line. Either inner band in Figure 3C is an acceptable output band.

Uncertainty of instantaneous slope—a tangent drawn to the output curve (Figure 2) at any point may differ in slope both from nominal and average slopes. This instantaneous slope specification establishes, within the relatively narrow linearity band, an even stricter limitation governing the output's stepwise characteristic, Figure 3D. Specifically, it limits the input increment which is required to produce an arbitrarily defined output increment. Such an uncertainty is related to instrument resolution.

The balance of this article details the specification, origins, and testing of instrument zero uncertainties. A subsequent article will examine uncertainties of scale factor and instantaneous slope.

UNCERTAINTY OF ZERO

Ideally, an instrument's output is zero in the absence of an input. Practically, a number of factors combine to produce some null output. The null output components for an ac signal may be classified as: fundamental in-phase (real), quadrature, harmonics, and noise. The ideal null signal contains a zero in-phase component; the other components need not equal zero, but must not exceed values specified by the user. For practical reasons the specification of zero uncertainty must concern itself with the in-phase component only, with particular care taken to specify the method by which this component is measured and to specify the limiting values of the

other signal components. All specifications concerned with zero uncertainty refer, then, to variations in the fundamental in-phase component only—or to dc output if the instrument is a dc device.

In complex electromechanical instruments, and even simple ones, many internal and external factors cause zero uncertainty. Some factors are theoretically unavoidable; others are unavoidable for practical reasons. Among these factors are manufacturing misalignment, ambient temperature variations, hysteresis, input from a theoretically nonsensitive direction (perhaps due to misalignment), linear and angular acceleration, linear and angular vibration, and shock. The first three—misalignment, temperature variation, and hysteresis—occur in most instruments and will be typified in detail by reference to how these errors arise in an ac rate gyro. It is recognized, however, that a complex instrument like a gyro is subject to zero uncertainties from all the factors named.

Manufacturing misalignment

As assembled, practically all transducers like rate gyros require fine adjustment of the in-phase component (of the signal voltage from the gyro's pickoff, the angular variable differential transformer) to approximately zero. This is due to misalignment or noncoincidence of the mechanical and electrical nulls. Most gyros, as shipped to the user, have factory sealed adjustments. Due to inaccurate factory settings or to effects of aging and handling, the installed gyro may conceivably have an appreciable residual null signal. The importance of this effect depends on the user's circuitry. If the residual null can be washed out by a circuit adjustment, then the user may simply specify that the in-phase component as shipped does not exceed the range of his adjustment. Otherwise, the user may require that this null be within very small limits.

Ambient temperature variations

The effects of wide temperature variations on instruments like unheated rate gyros can be an important source of zero uncertainty. The complex distribution of thermal stresses affects such sensitive elements as differential transformers and restraining springs to the extent that in-phase fluctuations result from ambient variations. To test the thermal null stability it is first necessary to make the instrument operate at the reference conditions from which deviations are to be measured.

User specifications should include as much data as possible about ambient temperature and all anticipated installation conditions affecting dissipation of internally generated heat. What is of ultimate importance is that the instrument be subjected to the same thermal environment during test as during actual operation.

The way the user specifies the environment will largely determine the test procedures, equipment, and instrumentation. The temperature chamber should be large enough to prevent the instrument's own dissipated heat from affecting the artificial environment, except where this effect may occur in actual use and is to be reproduced during test. Temperature measuring instruments should be properly located to monitor conditions adjacent to and right on the instrument case. The instrument should be mounted with isolation from externally induced vibrations such as sometimes caused by test chamber fans, which may cause spurious null fluctuations.

The chamber capacity should permit those rapid temperature changes (possibly temperature shock) the user might require. Since operation at high altitudes generally results in much higher internal gyro temperature rises than at sea level, the most severe high temperature test should be performed at simulated high altitude. If the expensive equipment required for this test is not available, then frequently an adequate compromise is to compute or even test the difference between the case temperature rise at sea level and at altitude. Then the zero uncertainty test can be performed at sea level, but with the top ambient temperature raised above normal to compensate. The final criterion is to reproduce the correct instrument case temperature, both for high temperature at high altitude and for low temperature at sea level conditions so as to simulate the true environment.

Hysteresis

Mechanical hysteresis prevents the output at null from always repeating exactly. Hysteresis is broadly associated with the concepts of threshold and resolution in the sense that the amount of hysteresis present is considered indicative of the instrument's ability to discern small input increments. There are two principal sources of hysteresis present to varying degrees: solid friction and bearing friction.

Solid friction—internal molecular friction in mechanical restraints (say, a spring) prevents relaxation of the member to its original position after removal of a torque or force. Hysteresis due to solid friction is shown in Figure 4A. Here point A represents the zero output at zero input. Increase of input magnitude, and therefore increase of spring torque and stress, to point *B* is characterized by the approximately linear input-output relation. When the input is reduced to zero again, the output falls back to C, since solid friction prevents the complete return. Reversal of the input direction to point *D*, followed by reduction to zero and increase again to *B*, completes the cycle. Hysteresis is defined in input terms as *AF* or, as $(AF/AG) \times 100$ percent of full scale. It can also be defined in output terms as $(AC/AH) \times 100$ percent.

Bearing friction—bearings impose relatively constant friction torque, which is fairly repeatable under given environmental conditions. Hysteresis due to bearing friction is shown in Figure 4B.

Note the very essential distinction between hys-

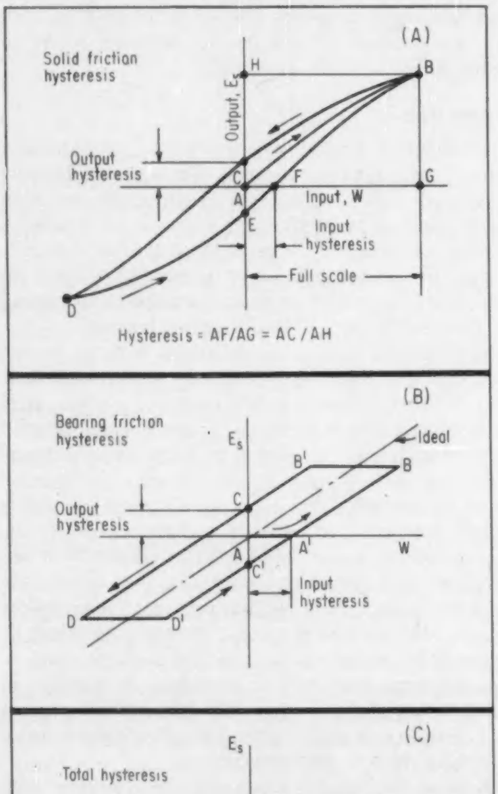
teresis due to solid friction and that due to bearing friction. In Figure 4B it is necessary to apply an input AA' to overcome the constant friction level before the output signal will be observed, while for the solid friction of Figure 4A an input increment is always accompanied by an output increment. Note also that reducing the input excursion reduces the magnitude of the observed hysteresis for solid friction, but with bearing friction the observed hysteresis remains unchanged since it is directly proportional to the bearing friction level.

It is usually necessary to specify hysteresis as a separate uncertainty item because, as will be shown in the succeeding article, an instrument with good resolution, as in Figure 4A, will not necessarily also exhibit a low hysteresis level.

With both solid and bearing friction present, a test loop for specifying hysteresis might appear as in Figure 4C. Hysteresis is best specified by describing the test procedure.

- Under stated environmental conditions establish output at zero input.

FIG. 4. Hysteresis contributes significantly to zero uncertainty.



- Slowly and smoothly increase the input in one direction (CW) to full scale; maintain full scale for some specified time interval; then slowly and smoothly decrease input to zero.
- Observe the output at this point (point C).
- Increase input to full scale in the opposite (CCW) direction; hold; decrease to zero.
- Observe output at this point (point C′).
- Compute hysteresis:

$$H = \frac{\text{Total hysteresis}}{\text{Total spread}} \times \frac{H_t \times 100}{2 \times \text{full scale}} \text{ percent}$$

Performance of the test cycle over the full operating range of the instrument insures that the solid friction effect will not escape observation. Control of time during the hysteresis test is essential in order that creep or recovery effects do not mask the true hysteresis effect. The apparent hysteresis will, for certain spring materials, show a marked dependence on the length of time the maximum stress is maintained and on the rapidity with which output is read after removal of stress.

Total zero uncertainty

Each effect contributes to some measurable output signal despite the absence of an input. The user must accomplish three things when he writes the zero uncertainty portion of the instrument specification.

1. He must specify the maximum total zero uncertainty which all the combined individual sources can produce. Suppose, for example, that the various maximum uncertainties which each of the sources can contribute are designated as A, B, C, . . ., etc. Now there is only a remote possibility that at some instant all uncertainties will be at their maximum values and, furthermore, will be adding in the same direction to produce a total zero uncertainty of A + B + C + . . . etc. Practically speaking, the magnitudes and directions of the uncertainties are reasonably random unrelated functions, giving justification for adding them statistically rather than arithmetically. The total zero uncertainty U_Z can be designated on the basis of probability theory as

$$U_Z = (A^2 + B^2 + C^2 + \ldots)^{1/2}$$

In other words, practically all of the time (perhaps 95 percent) the total uncertainty is less than the square root of the sum of the squares of the individually tested or computed uncertainties.

2. He must specify the maximum permissible magnitude of each individual uncertainty having particular significance. For example, in a rate gyro maximum uncertainties due to hysteresis and angular velocity are often individually specified.

3. He must list all uncertainty sources to be included in the total zero uncertainty U_Z, although he will, as noted above, specify the individual uncertainty contributions of some of them. This permits the manufacturer some flexibility in controlling the individual values, provided that the statistical sum does not exceed the permissible maximum.

Steel Opens Three Doors to Automatic Data Processing

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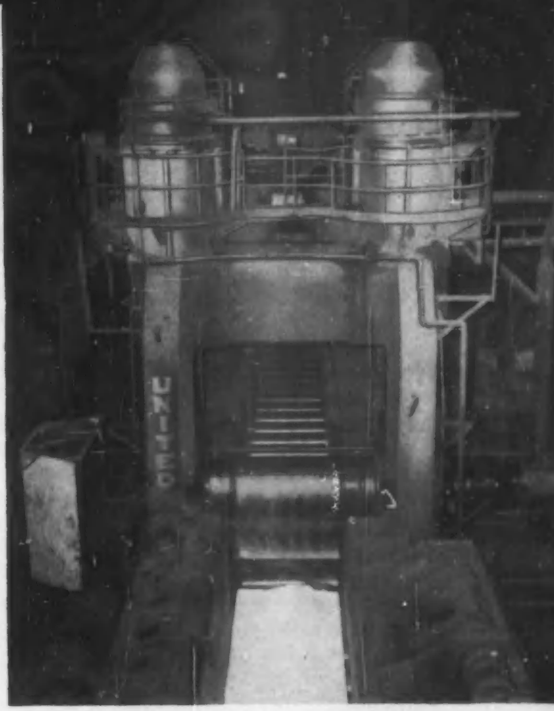


FIG. 1. Slabbing mill reduces ingot to thickness of 2 to 7 in. in several passes.

The steel industry's sudden drive to put automatic data processing equipment to work on the mill floor stems from three motives. First of these is the need to mechanize the great amount of information handling associated with each order as it progresses from ore to final product. Second is the desire to learn more about process dynamics by massive, high speed collection and analysis of test data. Finally, there is interest in the product improvement and operating economies made possible.

While the term "steel making" may seem to refer to a specific, homogeneous production effort, it actually covers a wide range of vastly different processes and operations, each of which is a separate entity, complete within itself. This diversity is compounded by the fact that the individual processes are batch type, wherein each order or heat is probably of a different metallurgical specification, receives different treatment at each stage in the finishing process, and is then delivered to meet a particular need of a particular customer. Because each process operates as a separate unit, and because each batch of material going through that process is earmarked for a specific purpose, steelmakers must interchange an enormous amount of information—from the incoming orders through the scheduling of a heat on the open hearth and down to final finishing and delivery.

Its ability to mechanize this information handling alone should make automatic data processing equipment attractive to the steel industry. In addition, automatic data processors make feasible the analysis of existing processes to pave the way for successful applications of more sophisticated control and measuring equipment. In the past, individual processes have been subjected to considerable study aimed toward upgrading their level of automaticity and achieving more efficient operation. However, these efforts have been handicapped by the difficulty of obtaining adequate knowledge of process dynamics—a difficulty caused partly by the lack of the necessary measuring instruments and transducers, and partly by the unavailability of means for automatically analyzing and handling large volumes of data.

Although digital computers and business data processing equipment are being used in many steel mill offices, few applications of production-type data handling equipment have been made. It might appear that the industry is approaching this new technology with undue caution, especially in view of the incentives outlined above. This reluctance can be attributed to several reasons which are undoubtedly common to many other industries as well, although perhaps not so critical as in the steel industry. In the first place, the steel-mill environment is one of the worst to which electronic apparatus can be exposed. In fact, for many years there have been two standards of industrial electrical apparatus: one is for general-purpose and the other for heavy industry or steel mill

equipment. Steel mill relays and contactors are oversize and overrated; much attention is paid to extreme reliability and long life. Enclosures for control equipment are made exceptionally rugged to withstand rough handling in installation and operation.

All steel mill processes are around-the-clock operations with a scheduled down time of eight hours per week, maximum. Thus, apparatus that may require more than this amount of scheduled down time has only limited appeal. The financial loss from accidental or unscheduled down time is so great that equipment must be designed for the highest reliability; marginal equipment must be limited.

Another problem in the application of data processing equipment to steel mills is the lack of a complete line of transducers and instruments to extract and record the essential data. The transducers that do exist are intended more for use by laboratory technicians than by mill personnel. Such transducers would have a limited life if applied in a mill. And for many process variables, transducers for direct measurement are not available at all. Thus, application of complex control equipment must in some cases await the development of suitable transducers.

Flat rolled products

A better understanding of the opportunities, as well as the problems, associated with the application of data processing can be gained with a brief examination of the principal processes involved in making one type of steel, electrolytic tinplate. This is a low carbon steel strip plated on both sides with an extremely thin layer of tin. The procedure begins with the open hearth furnace, in which iron is made into steel. In the open hearth process, which accounts for approximately 89 percent of the steel produced today, molten pig iron from the blast furnace is combined with steel scrap, limestone, ore, and other materials. The total charge is melted and then refined by an oxidation process, which is carefully controlled to yield steel of the desired composition. The finishing temperature of the molten bath is about 3,000 deg F and varies according to the grade of steel specified. When the furnace is tapped, the steel flows into a ladle where alloying elements such as chromium, manganese, aluminum, boron, titanium, vanadium, and zirconium are added to bring the steel to the correct alloy specification. Next, a crane transports the ladle to the ingot-pouring or teeming track, which has a series of molds prepared to receive the molten steel. After pouring, the ingot cools until the outer portion has solidified sufficiently to allow stripping or removing the mold. Before it can be rolled or processed further, the ingot must reach a uniform temperature throughout. This is done by placing the ingot in a large furnace known as a soaking pit. Here the extremely hot or even still molten center cools while the exterior is reheated.

The mechanical treatment of the steel, from ingot to the final product, is divided into the main categories of hot and cold working. The exact processing routine varies over a wide range, depending on what the final product shape is to be. For sheet or strip products, the slabbing mill, Figure 1, reduces the ingot to a slab ranging from 2 to 7 in. in thickness and from 12 to 64 in. in width. The slab is run through the mill several times, with a reduction being made in each pass. Next the ragged front and tail ends are removed by a large crop shear and the slab is cut to the required length—usually 5 to 20 ft.

In some mills the slabs continue directly on to the succession of passes in a reversing mill or several separated nonreversing mills, then in a tandem finishing mill. More commonly, however, the slab is allowed to cool to allow for manual inspection and conditioning of the slab surface; surface defects can be cut or burned out here. After conditioning, the slab enters a reheat furnace to prepare it for the hot strip mill, which normally consists of a tandem arrangement of six individual roll stands about 20 ft apart, each having its own individual drive motors and control. As slab thickness is reduced progressively, the roll speed for each succeeding stand is increased to accommodate a longer length of metal. In addition to accurate data on speed control requirements, the information given for the hot-strip-mill stage usually includes a minimum temperature for strip emerging from the last stand as well as a maximum temperature for strip entering the coilers.

After descaling in a pickling line, the strip progresses to the cold strip mill, which for tinplate is usually a 5-stand tandem unit. The purposes of cold rolling are to reduce the thickness to the final product size, to produce a smooth, dense surface, and to develop the desired mechanical or grain structure properties. The thickness of tinplate ranges between 0.006 and 0.015 in. After passing through an annealing stage and a temper mill (where a small reduction is taken to establish the desired steel temper), the steel strip is ready for the final process of tinning.

Most tinplate is produced on continuous electrolytic lines where the entering coils are welded together to form a continuous strip. In the electrolytic process, bars of pure tin form one electrode, and the steel strip forms the other. The amount of tin deposited is controlled by means of the plating current; it is possible to have coatings of different weights on the top and bottom of the strip. The customer's requirements determine the coating thickness, which ranges from 6 to 60 microin. At the delivery end of the line, the tinplate is cut to the desired sheet length or recoiled in 10-30,000-ft. lengths.

While necessarily brief, this description should provide a clue to the complexities of steel making. Several vital links in the chain of processes were omitted; for example, no mention was made of the blast furnace operation in which iron ore is reduced to liquid nor of the coke ovens for burning off the impurities in coal. And it must be remembered that the discussion was limited to tinplate. Equally

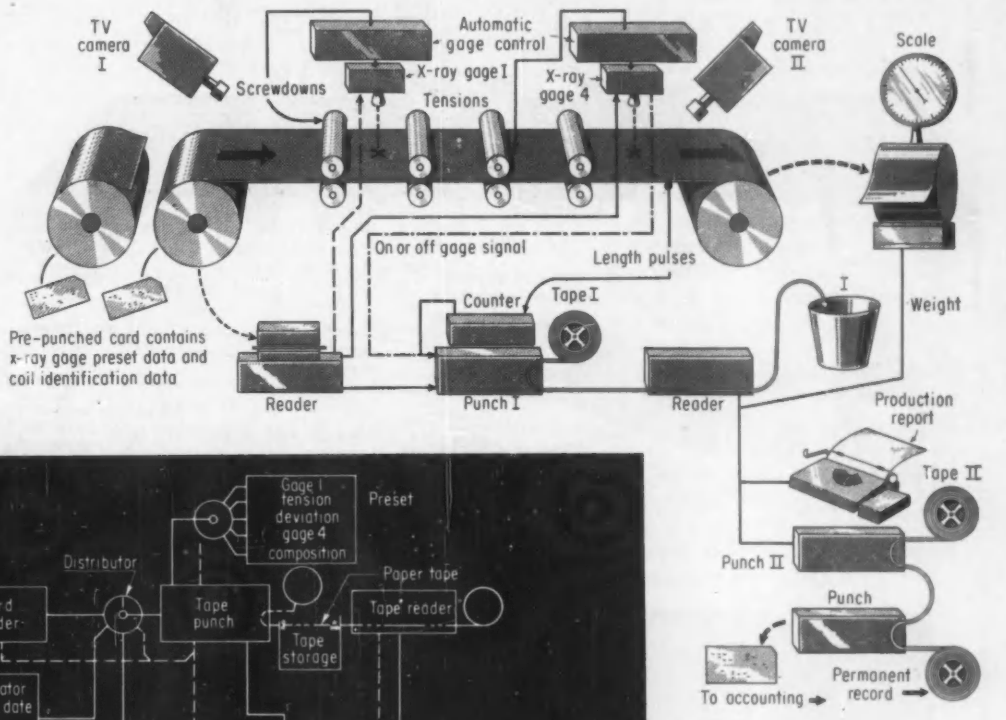


FIG. 2. Data logging and X-ray gage programming system for tandem cold reduction mill.

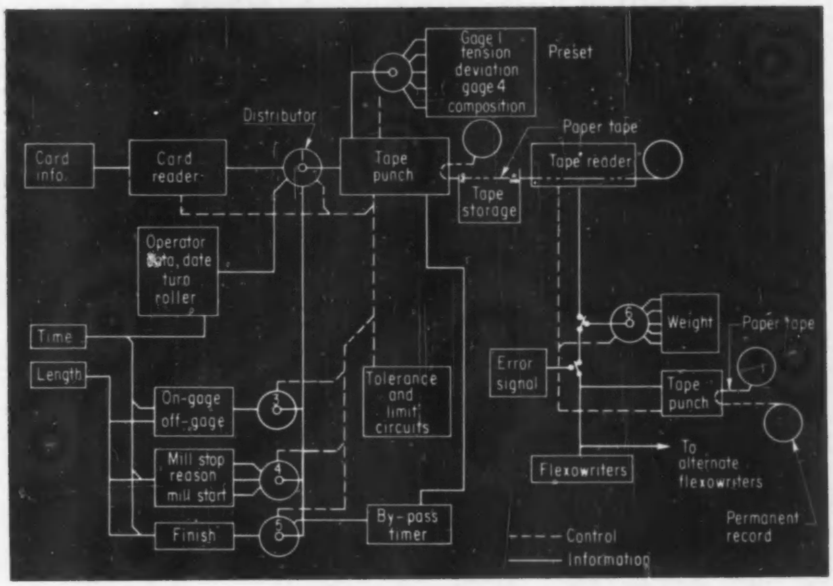


FIG. 3. Block diagram of control and data gathering equipment used on tandem mill.

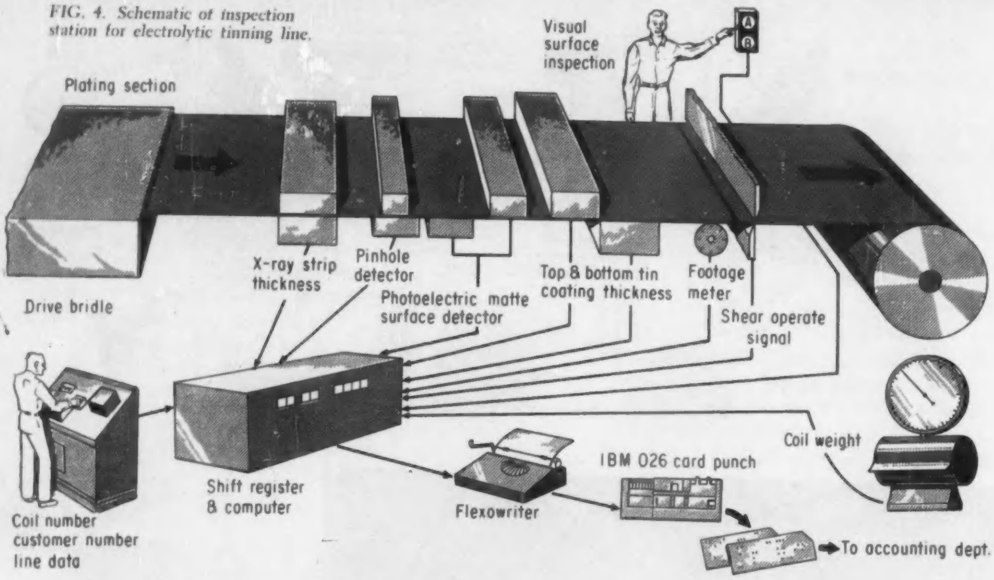
lengthy routines could be written for hundreds of other forms of basic steel products.

Place for data processing

How does data processing and data logging fit into this complex steel business? Probably the easiest way to answer this is to examine some specific operations in detail. Charging an open-hearth furnace, for example, presents two problems that can be solved only after a certain amount of computation. The first requirement is to determine the proper proportions of incoming materials needed to meet the specifications laid down for the final product. This determination is complicated by the fact that the exact nature of the pig iron from the blast furnace changes constantly because of variations in the grades of ore, even when all of the ore comes from the same mine field. Pig iron contains large and fluctuating amounts of the element phosphorous. In the open hearth the phosphorous is combined with limestone to form the slag that floats on the top of the steel bath. The amount of phosphorous in the pig iron partially determines the weight of limestone to be added. The limestone tonnage is dependent further on the amounts of silicon and sulphur in the total charge, as well as on the percentage of lime actually in the limestone. Limestone may contain other impurities requiring additives for counteraction. And there may be several grades of limestone, having different lime concentrations and different impurities.

The ratio of the weight of scrap to the weight of liquid or solid pig iron used in a charge is based largely on economic considerations, such as the availability of pig iron from the blast furnaces, the price of commercial scrap, and the supply of scrap produced as a byproduct in the mill operations. Another consideration affecting the batch proportions stems from the fact that iron ore serves not only as a source of iron but as an oxidizing agent as well. Thus, ore must be used in sufficient quantities to

FIG. 4. Schematic of inspection station for electrolytic tinning line.



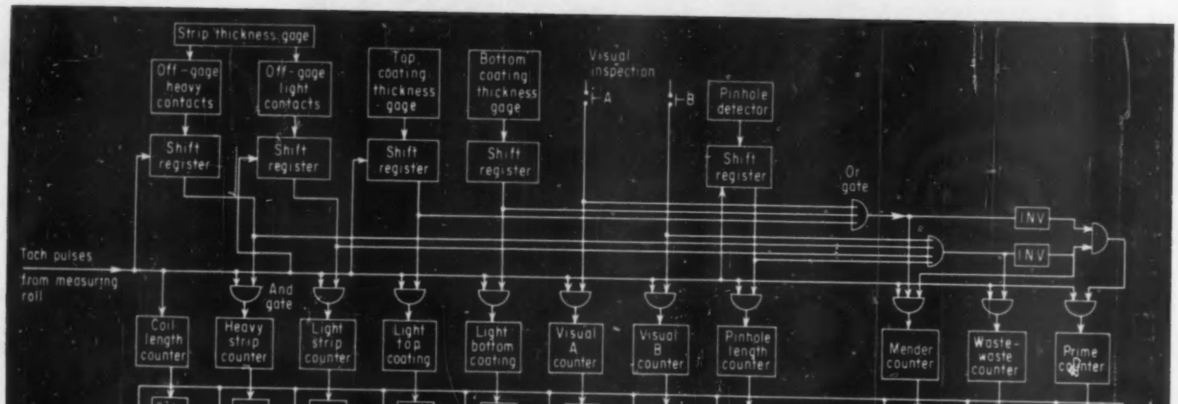


FIG. 5. Block diagram of inspection system shows shift registers used to coordinate information from all gages.

make up the difference between the oxygen available from all other sources and that needed.

It should be evident from this quick rundown of the major variables that calculation of the exact charging "recipe" is an extremely complicated procedure; each constituent in the mix affects the quality of the final product, and the amount of any one element used is complexly related to the economic and metallurgical aspects of all the other elements. Proper operation of the open hearth furnace is further complicated by the fact that several different firing cycles can be followed for the same output.

The programming of the charging process could be speeded greatly by a data processing and computing system with the ability to calculate the optimum combination of charging materials. The equipment would require inputs (either automatic or manual) providing information on raw material composition. The computer program would be written from data combining theoretical chemistry with the practical experience of the "first melter". Given the final steel specification, the computer would advise on the optimum amounts of each of the raw materials, the firing routine, the time in the cycle at which liquid iron ore is to be added, and many other guides.

Data logging

The foregoing leads logically to the second operating area where data processing can be of help. Because the environment of an open hearth shop that feeds about 10 or 12 furnaces is an extremely busy one, it is difficult under present practices for the operators to keep an accurate record of the materials charged. A much finer check on operating practice is needed if the benefits of optimizing charging equipment are to be fully realized. This finer check can be made by means of an automatic data logging system tieing together the operations of the charging floor with those in the bulk materials handling areas. After the optimum material weights had been determined by the computer, the data logger would take over to maintain an accurate record of the materials actually charged and to insure that the recommended program is being followed.

The concept of automatic data processing represents a major step in open hearth operations that will not be taken hastily. At present the operators rely heavily on "good judgment" to solve the peculiar problems that arise. This good judgment is hard to reduce to formula; and it is even more difficult to measure the phenomena by which the operators detect that a problem existed in the first place. Yet, any equipment that does not include a large percentage of the operators' good judgment and inherent gaging abilities will be of little use. And there must be no doubt about system reliability.

Work is progressing at a rapid rate, but no "crash" programs are expected. Each change must prove in advance that it will pay its own way. Competition is keen among the steel companies—so keen that many new control concepts are first tried and applied here. But major shop modifications or some forced down time can wipe out anticipated savings quickly.

Strip mills

The tandem cold reduction mill is one area in the steel mill where data processing equipment has already been applied. Here, the important product parameter is final strip thickness. A recently supplied system, Figure 2, was to include an automatic gage control system that logged data only for process evaluation and to help during the initial adjustment period. However, it was soon realized that the gage control could supply data for accounting and quality control purposes as well. The automatic gage control equipment includes X-ray gages for the strip thickness out of Stands 1 and 4. The gages are automatically preset to the desired product thickness.

Figure 3 shows a block diagram for the system. A punched card prepared in the production office accompanies each coil to the rolling mill. When the coil is started through the mill, the card is inserted into a card reader and the two X-ray gages are set automatically to the proper nominal thickness and the proper tolerance band. In addition, the tension limit setting for the gage control system is adjusted for the particular product. Other data on the programming card is for coil identification and includes coil number, customer number, and order number.

A measuring roll rides on the strip and drives a tachometer system that delivers one pulse for each 10 ft of strip. A pulse counter indicates the length of the coil that has passed through the mill. Whenever the strip thickness moves out of tolerance, a signal is sent to the paper-tape punch I, which records the length from the lead end of the coil in binary-decimal code. When the gage signals a return to tolerance, the length is again punched on the tape.

Tape I is used primarily for buffer storage and records fixed data first, followed by the production data. The coil weight must also be added to the record, but this data is not available for several minutes after the coil has left the mill. Because it is possible for several coils to be in transit between the windup reel and the weight scales, the tape must store data previously recorded for each of these coils until its weight reading is taken. After this is done, tape I advances to the tape reader where all the punched data is read out. The final production report is prepared on an electric typewriter and, simultaneously, a new paper tape is made to provide a permanent record of the production run. Now paper tape I, which has served its function, is scrapped. Tape II is available for any subsequent handling of the data, such as for payroll calculations. For the latter, the punched tape is transported to the accounting department at the completion of each shift. A tape-to-card punch makes up punched cards containing the pertinent data.

A digital clock mounted on the operator's console supplies time signals for both the start and finish of

a coil. It also provides the time reference needed for recording the occurrence of abnormal conditions such as a mill shutdown. In the event of the latter, both shutdown and restart times are recorded as well as a code number identifying the reason for delay. Although the data processor is a relay and stepping switch system, it is fast enough to control the relatively slow mill speeds. The equipment is placed in an adjacent air-conditioned room.

Electrolytic tinning lines

Within the last two years, the can companies have begun purchasing tinplate in coil form. Previously the steel companies sheared the tinplate into small sheets, which were inspected and graded before shipping. The new practice created the need for an automatic inspection system plus a data processing system to correlate the information from all the gages into one consolidated report. The report is shipped along with the coil to guide the user.

A sketch of the inspection station on the delivery end of an electrolytic tinning line is shown in Figure 4. The system features a footage pulser, which consists of a hardened, accurately machined wheel riding on the strip and a pulse tachometer. This combination supplies one pulse per foot of tinplate and the total number of pulses between successive shear pulses corresponds to coil length.

One channel with a counter and a gating circuit is provided for each of the inspection gages to record the lengths of various types of defects, Figure 5. When an inspection gage notes a defect in a particular channel, a signal is sent to a gate, admitting the footage pulses into the corresponding counter. At the same time, the equipment automatically makes a decision regarding the quality of the strip. Strip having no defects is classed as prime strip; the length of such strip is measured by gating the footage pulses to the prime counter. Defects relating to the tin coating are defined as mender quality and are recorded by the mender counter. Mender defects include excessive deviations in top or bottom coating thickness, the presence of matte or unmelted coating, and one class of visual imperfections. Defects in the base metal are counted in the waste-waste counter and embrace off-gage strip thickness, pinholes, and the second class of visual flaws.

Because the gages are physically displaced from one another, signals that are generated simultaneously by two different gages do not refer to the same foot of tinplate. To bring the signals from all gages into space correspondence, it is necessary to delay the information received from the first gages for a particular section of strip until the last gage has scanned the section. This is accomplished by means of transistorized shift registers which store the data from each gage. The individual registers are set to read out the stored information after the number of pulses that correspond to its distance from the reference point has been received. In addition to the data collected automatically from the inspection gages, certain coil identification information is inserted manually by means of industrial-type selector switches. A digital electric clock supplies time information.

After a coil is completed, the tinplate is removed from the reel, placed on a scale, and its weight recorded. The data in all counters is then transferred to transistor buffer storage units and the counters reset for the next coil. Next, hermetically sealed stepping switches move the data from buffer storage to an electric typewriter and card punch. The completed record also documents shutdowns, including stop time, restart time, elapsed time, and cause.

The functions performed by this equipment are similar to those of the tandem cold mill data system. The higher operating speeds, though, make it necessary to use electronic components rather than relays. The circuitry for all stages is completely transistorized and mounted on printed wiring plug-in boards.

Design criteria

Full scale data processing can be properly applied only after a complete investigation into system requirements. Most of the existing mill operations are based upon manual control, manual data transfer, and human decision making. Many times an automatic system is badly hampered from the start if it is designed to closely follow the manual patterns that preceded it. However, it is necessary that existing methods of operation be given careful consideration. In planning the new control system, all abnormal conditions must be recognized, and their specific remedies spelled out in detail. It is necessary also to take into account system reliability and the effects of system failures. This aspect has been helped somewhat by the earlier application of certain types of advanced controls to individual processes. Thus some components that are new to the steel mills have already proven themselves. As operators become familiar with simpler systems, the possibilities and requirements of larger systems become clear.

Steel mill operators have already recognized the benefits to be gained through the automatic collection of data for use by various operating departments, such as accounting and quality control. They know too that a first step toward automatic control of processes is statistical correlation of operating parameters for optimum performance.

The present systems are mostly tailored for application to one specific process, or at most several closely related process. Hence these systems have been difficult to justify economically; the gains may not be large enough to warrant the expense. The biggest gains will be achieved when it is possible to have a large scale system engineered to include all the steel processes. Such a system would coordinate all record and accounting functions with the production operations. While there are many obstacles that will cause the steel mills to proceed cautiously, the significant fact is that they are proceeding.

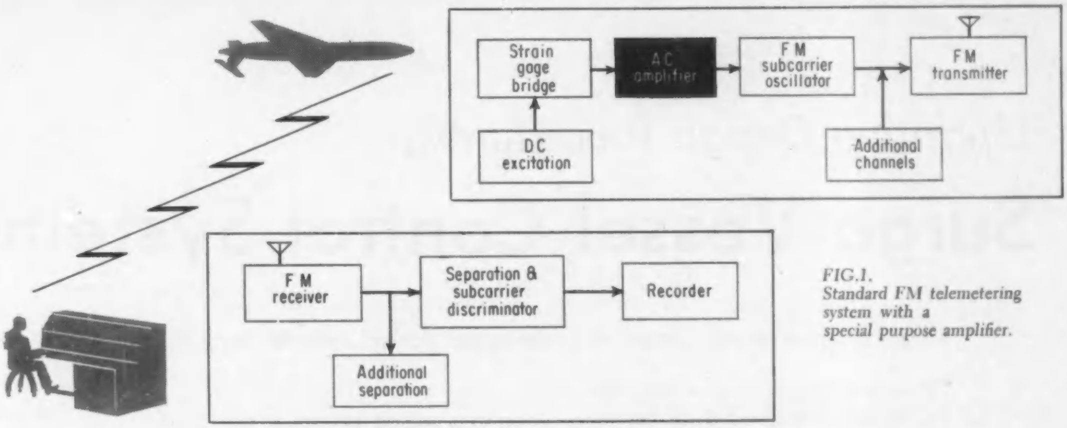


FIG.1.
Standard FM telemetering system with a special purpose amplifier.

Special Amplifier Aids Flutter Testing

JOHN C. CARPENTER
Radioplane Div., Northrop Corp.

One phase of modern airframe flight testing involves an investigation of flutter in control and other flight surfaces. Flutter is a mechanical oscillation that occurs in flight structures having characteristics similar to a spring-mass-dashpot system with a natural frequency, a damping ratio, and a single degree of freedom. Flutter is not limited to the characteristics of a second order system; order may be any higher than first.

Cause of flutter is assumed to be a high amplitude, short duration, impulse signal which contains the entire frequency spectrum. The purpose of flutter testing is to determine whether a particular surface, subjected to such an input, will oscillate, and if so, whether the oscillation amplitude decays in time, remains constant, or becomes dangerously high.

Instrumentation

Figure 1 shows a system designed to evaluate the flutter characteristics of an unmanned rocket-powered drone. Standard FM/FM telemetering equipment provides the data transmission. Conversion of the mechanical oscillations into electrical signals suitable for transmission, however, requires interesting circuitry.

Four-element strain gage bridges, because of their size and weight, provide the initial conversion. These must be carefully applied to the surfaces under test so as not to alter the original characteristics. High level dc excitation produces a maximum output. Neither bridge balance nor static drift presents any problem since the dc component is not sensed.

Special Amplifier

Normally, flutter occurs in the frequency range of 5 to 200 cps and has a low damping ratio. It differs from both vibration and stress which, for test purposes, must be isolated from the flutter signals. A special ac amplifier follows the strain gage bridge (Figure 1) and is shown in Figure 2.

Transformer T_1 isolates the ac component of the input and provides a 6 to 1 step-up ratio. Potentiometer R_1 serves as a terminating resistance for the transformer secondary and as a means of input attenuation. The amplifier uses two medium-mu twin triodes connected as shown. Rheostat action of R_9 allows an adjustment of the dc output level to match the input range of the FM subcarrier oscillator. Coupling capacitor C_2 controls low frequency roll off; C_1 and C_3 perform the same function at the upper end. Amplifier characteristics include a maximum gain of 1,000, good linearity, and a fairly flat response which is down 3 db at 5 and 200 cps.

Before a flight test, the system is calibrated by using a vibration head or driver to induce a mechanical oscillation at the natural frequency of the surface to be tested. Amplitude of the recorded demodulated signal is brought to the desired value by adjusting the amplifier sensitivity.

When the vehicle is airborne, relatively fast transients are inserted into its controls to induce flutter in the surfaces under investigation. Observation of the recorded signals at the receiving station permits continuous monitoring of the flutter parameters.

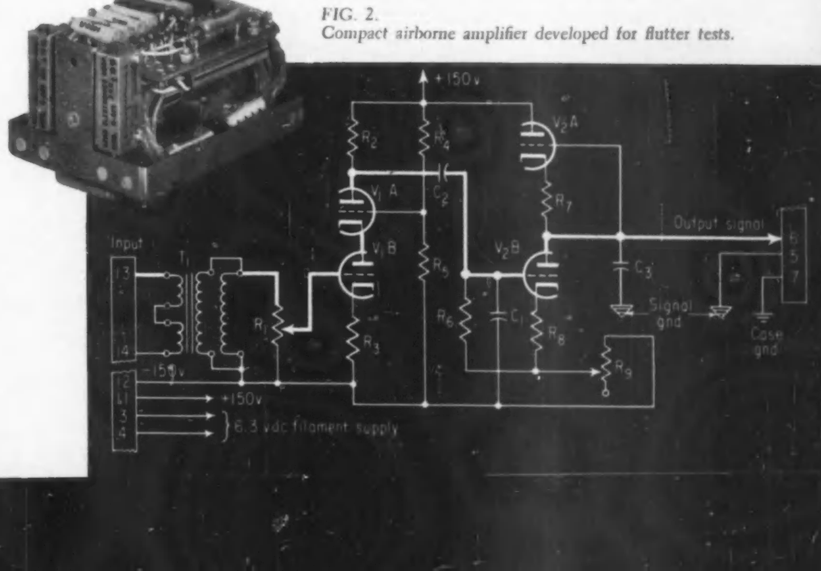


FIG. 2.
Compact airborne amplifier developed for flutter tests.

Updating Design Procedures for

Surge Vessel Control Systems

To guide the economic design of surge vessel control systems, author Otto offers—

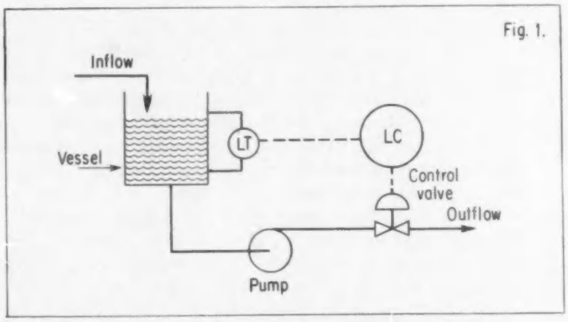
- **Practical application equations**
- **Original tabulated data for these equations based on vessel size and position, valve type, and controller settings**
- **Examples of when to add more costly instrumentation to save by reducing vessel size**

KENNETH A. OTTO, The Dow Chemical Co.

Optimum performance of many chemical, petroleum, and other fluid operations often depends on relatively constant feed flow to various steps in the process. Surge control systems achieve this smooth feed. In equipment configuration a surge control system is identical to a level control system. Figure 1 shows a typical equipment setup. However, the functions of level and surge control systems are completely different. A liquid level control system maintains a relatively constant level in the vessel, especially in the presence of inflow disturbances. Such an objective allows this inflow disturbance to be reflected on the outflow as shown in Figure 2A. A surge control system, on the other hand, maintains a relatively constant outflow in the presence of an inflow disturbance. This objective essentially allows the inflow disturbance to vary the level, holding the outflow change to a minimum, Figure 2B. Level control uses a narrow controller proportional band, and fast reset if necessary; surge control, a wide proportional band and slow reset.

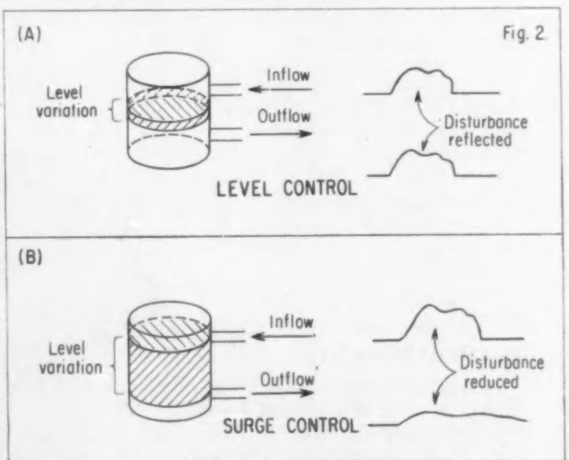
In both level control and surge control the outflow always equals the inflow in steady state. The difference is that surge control purposely takes longer to reach steady state after a disturbance.

The design of surge control systems to achieve desired performance requires that consideration be given to the static and dynamic characteristics of each piece of equipment in the control loop. In practical cases however, the dynamics of several elements in the control loop can be neglected—which simplifies considerably the design of actual systems. The diagram, Figure 3, of the surge control system contains blocks representing elements or pieces of equipment in the system. Each block should normally include steady state and dynamic characteristics for that equipment. Field correlation



Level and surge control systems have common equipment . . .

. . . but here's how they differ in function.



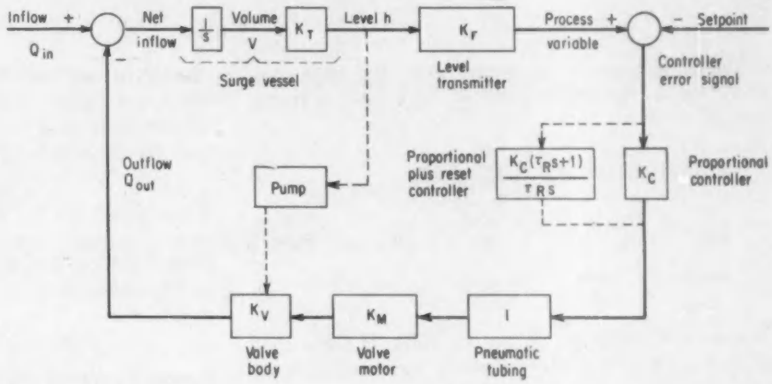


FIG. 3. Surge control system, showing all steady state gain terms but only those dynamics terms significant in practical applications. Table I, based on a study of actual equipment, defines the gain terms of each piece of equipment in the system.

and analog simulation studies showed that, to an excellent first approximation, all dynamics except for the tank itself and the controller reset action—when used—could be neglected and that only the steady state terms need be considered. Table I lists the steady state (gain) terms. The gain terms form the basis for the design of surge control systems.

Surge systems using proportional control

Using proportional control action only and considering the surge tank as the one element exhibiting a dynamic effect, a realistic approximation of the closed-loop transfer function of the system is:

$$\frac{Q_{out}}{Q_{in}}(s) = \frac{1}{\tau s + 1}$$

where τ is the time constant. The transfer function relating volume change and inflow is:

$$\frac{V}{Q_{in}}(s) = \frac{\tau}{\tau s + 1}$$

These transfer functions show that following a step change in inflow of magnitude ΔQ_{in} the outflow changes exponentially until it equals the new value of inflow, and the volume change exponentially approaches a total change or constant offset equal to $\tau \Delta Q_{in}$. For such a single-order system the outflow's maximum rate of change occurs at $t = 0$ and equals:

$$(dQ_{out}/dt)_{max} = \Delta Q_{in}/\tau \qquad (1)$$

For simplicity, $(dQ_{out}/dt)_{max}$ will be abbreviated as $(dQ_{out})_{max}$.

The performance of the surge vessel system using proportional action can be completely specified once the time constant is determined. The time constant is the reciprocal of the open-loop gain,

$$1/\tau = \text{loop gain} = K_T K_V K_M K_C K_F \qquad (2)$$

Some gains are nonlinear and vary with such factors as flow rate and liquid level. However an excellent approximation to them can be found by considering their values at the operating regions. Pertinent discussion for each gain parameter is in Table I.

Table II, combining information in Table I and Equation 2, contains the time constants for various equipment configurations. (The data in Table II applies where the pressure drop across the output valve is reasonably constant, about 75 to 110 percent

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TABLE I
SURGE SYSTEM GAIN COEFFICIENTS

The surge system gain coefficients, using pneumatic instrumentation, are:

1. Transmitter gain, K_F

K_F = (output psi change)/(foot level change)

$(15 - 3)/h_{max} = 12/h_{max}$ psi/ft

In a differential pressure cell transmitter, the gain K_F is incorporated in the range adjustment mechanism. In a float transmitter, K_F is picked when the float length is specified, and K_F then corresponds to the integrally mounted controller's output signal with 100 percent proportional band.

2. Controller gain, K_C

K_C = 100/(percent proportional band)

3. Valve-motor gain, K_M

K_M is slope of valve travel vs diaphragm pressure. The plot is essentially linear, except for a slight curving near the minimum pressure of 3 psi. The linear plot for one typical valve motor intercepts to zero travel at 3.2 psi.

$$K_M = \frac{\text{(100 percent valve movement)}}{\text{(15 psi} - \text{3.2 psi)}} = 8.5 \text{ percent/psi}$$

4. Vessel gain, K_T

K_T = height/volume. For a vertical cylindrical tank with constant cross-sectional area the value for K_T is:

$$K_{TV} = 1/A = h/V \ 1/\text{ft}^2$$

The cross-sectional area of a horizontal cylindrical tank varies with liquid level, and for the operating region of interest is:

$$K_{TH} = 1.2 K_{TV}$$

The factor 1.2 represents the approximate average value found in an analog simulation study.

5. Valve body gain, K_V

The valve body gain K_V is the most important gain parameter in the system. Its value depends on the flow-lift characteristics of the valve, on the pump head variation, and on the valve sizing procedure. It was found that a reasonably good approximation to K_V could be obtained from the flow-lift characteristic alone provided the pump's differential pressure remained within 75 to 110 percent of nominal. On this basis the value for the gain of a linear valve is:

K_{VL} = (maximum flow)/(maximum stem travel)

$K_{VL} = Q_{max}$/(100 percent) ft³/min/percent

For an equal-percentage valve sized to pass the normal flow at 70 percent open, the valve gain is approximately:

$$K_{VP} = Q_{max}/(40 \text{ percent})$$

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of operating value.) As an example, the time constant for a vertical cylindrical tank and a linear control valve is:

$$\tau = \frac{1}{K_{TV}} \times \frac{1}{K_{VL}} \times \frac{1}{K_M} \times \frac{1}{K_C} \times \frac{1}{K_F} \quad (2)$$

$$\tau = \frac{V}{h_{max}} \times \frac{100}{Q_{max}} \times \frac{1}{8.5} \times \frac{\%PB}{100} \times \frac{h_{max}}{12} \quad \text{From Table I}$$

$$\tau = \frac{0.985V}{Q_{max}} \times \frac{\%PB}{100} \quad (3)$$

Equation 3 and other entries in Table II show that the system time constant increases with tank volume and controller proportional band.

Rearranging Equation 1:

$$\tau = \Delta Q_{in}/(dQ_{out})_{max}$$

In other words, if the size of the step disturbance ΔQ_{in} and the maximum tolerated rate of change $(dQ_{out})_{max}$ are specified, then the system time constant is also specified. Once the necessary time constant is determined, sizing the vessel is easy.

As an example of vessel sizing, suppose the system uses a linear control valve, an upright cylindrical tank, and an integrally mounted level transmitter and controller whose proportional band is 100 percent (maximum). Further, assume the valve can pass 20 cfm (Q_{max}), the maximum tolerable rate of outflow is 0.1 cfm ($(dQ_{out})_{max}$), and the maximum step disturbance is 2 cfm (ΔQ_{in}). Then, from Equations 1 and 3 the required volume is:

$$\frac{\Delta Q_{in}}{(dQ_{out})_{max}} = \tau = \frac{0.985V}{Q_{max}} \times \frac{\%PB}{100}$$

$$V = \frac{\Delta Q_{in} \times \frac{100}{PB} \times Q_{max}}{0.985(dQ_{out})_{max}} = \frac{2 \times 1 \times 20}{0.985 \times 0.1}$$

$$V = 406 \text{ cu ft}$$

The volume change is:

$$V = \tau\, \Delta Q_{in} = (2/0.1) \times 2 = 40 \text{ cu ft}$$

The volume required (406 cu ft) is much larger than the actual surge volume change (40 cu ft), a situation usually encountered with a narrow proportional band controller. This suggests using a proportional band wider than 100 percent to reduce the required volume to four or five times the surge volume change. This approach is feasible; however the choice is usually an economic one involving a cheaper controller limited to 100 percent proportional band versus a more expensive one with a wider proportional band. The difference in instrumentation cost may be offset by the lesser cost of a smaller tank. If the economics dictated a more expensive controller, then reset action would be probably added as a control function. Reset, as will be shown, improves surge-reduction effectiveness and hence permits using an even smaller tank.

Probably the parameters most difficult for the design engineer to specify will be the size of the step disturbance and the maximum tolerable rate of change of outflow. For this reason the concept of reduction factor (RF) may aid in comparing the effectiveness of different surge systems. The reduction factor is defined as:

$$RF = (\Delta Q_{in})/(dQ_{out})_{max}$$

This factor can be thought of as representing the surge reduction capability of any given system. The larger the reduction factor, the better the surge effectiveness. For the previous example the reduction factor is:

$$RF = 2/0.1 = 20 \text{ (minutes)}$$

Surge systems using proportional plus reset control

When using proportional control action, a permanent offset in volume results following an inflow disturbance. This offset makes it mandatory to keep the available volume (V) much larger than the required volume change (ΔV). To overcome this offset, automatic reset action can be added to the controller with two resulting advantages:

1. Elimination of offset allows a minimum tank size to be approached where the minimum has a volume equal to twice the total required surge volume change.
2. The maximum output rate of change is held at the specified maximum for a longer time.

With automatic reset added to the controller the surge vessel system transfer function now becomes second order and can be represented by:

$$\frac{Q_{out}}{Q_{in}}(s) = \frac{s/\tau + 1/(\tau\tau_R)}{s^2 + s/\tau + 1/(\tau\tau_R)}$$

$$\frac{V}{Q_{in}}(s) = \frac{s}{s^2 + s/\tau + 1/(\tau\tau_R)}$$

where τ = system time constant; τ_R = reset time constant.

For surge control the best outflow transient is taken to be that with a unity damping coefficient ζ. In normalized form the following are obtained:

$$\zeta = \tfrac{1}{2}(\tau_R/\tau)^{1/2}$$

or, for unity dampening factor:

$$\zeta^2 = 1.0 = \tau_R/(4\tau)$$

or

$$\tau_R = 4\tau$$

Also

$$\omega_n = 1/(\tau\tau_R)^{1/2}$$

$$\omega_n = 1/T_n = 1/(4\tau^2)^{1/2}$$

or

$$T_n = 2\tau$$

where ω_n is the natural resonant frequency.

The minimum vessel size using proportional and reset control action is twice the required surge volume change, or $V = 2\Delta V$, considering both positive and negative disturbances and assuming the liquid is at mid-level before a disturbance occurs. For unity damping coefficient the maximum volume change following the inflow disturbance is:

$$\Delta V = 0.385T_n\,\Delta Q_{in} = V/2$$

or

$$\tau = V/(1.54\Delta Q_{in}) \quad (4)$$

The maximum rate of change of outflow occurs

near $t = 0$ and is:

$$\left(\frac{Q_{out}}{\Delta Q_{in}}\right)\Big/\left(\frac{t}{T_n}\right) = 1.43$$

or $$Q_{out}/t = (dQ_{out})_{max} = 1.43\ \Delta Q_{in}/T_n$$

or $$\tau = T_n/2 = 0.715[\Delta Q_{in}/(dQ_{out})_{max}] = 0.716\ RF \tag{5}$$

Equating Equations 4 and 5 and solving for volume,

$$V = \frac{1.1(\Delta Q_{in})^2}{(dQ_{out})_{max}} \tag{6}$$

This is the minimum vessel volume required to give an outflow maximum rate of change of $(dQ_{out})_{max}$ for an input step of magnitude ΔQ_{in}.

To achieve the optimum volume the system time constant τ is determined from Equation 5, and from this the required controller proportional band is found. For a vertical cylindrical tank and a linear valve, the time constant is, from Table II (or Equation 3):

$$\tau = \frac{0.985\,V}{Q_{max}} \times \frac{\%PB}{100} \tag{3}$$

Using Equations 3 and 6 and solving for the proportional band gives:

$$\tau = \frac{0.715\ \Delta Q_{in}}{(dQ_{out})_{max}} = \frac{0.985\left[\frac{1.1(\Delta Q_{in})^2}{(dQ_{out})_{max}}\right]}{Q_{max} \times \frac{100}{\%PB}}$$

or $$PB = \frac{66\,Q_{max}}{\Delta Q_{in}} \text{ percent}$$

For other vessel-control valve configurations the factor 66 will vary according to the appropriate time constant in Table II. These factors for setting controller proportional band for optimum (minimum) tank size are shown in Table III. They apply only when the controller has reset action.

The system time constant depends on both the desired reduction factor and on equipment configuration. The reset time constant depends, however, only on the desired reduction factor:

$$\tau_R = 4\tau = 2.86\ \Delta Q_{in}/(dQ_{out})_{max} = 2.86\ RF \tag{7}$$

USEFUL DESIGN DATA FOR SURGE CONTROL SYSTEMS

TABLE II

System time constants for different vessel and valve configurations.

Valve Type	Vertical tank	Horizontal tank	Comments	$K_P = 12/h_{max}$ $K_M = 8.5$ percent/psi
Linear	$\frac{0.985\,V}{Q_{max}(100/PB)}$	$\frac{1.15\,V}{Q_{max}(100/PB)}$	Valve sized to pass Q_{max} at full open. Operating point anywhere.	
Equal-percentage	$\frac{0.4\,V}{Q_{max}(100/PB)}$	$\frac{0.465\,V}{Q_{max}(100/PB)}$	Valve sized to pass Q_{max} at full open. Operating point 70 percent open.	
Needle	$\frac{0.52\,V}{Q_{max}(100/PB)}$	$\frac{0.57\,V}{Q_{max}(100/PB)}$	Valve sized to pass Q_{max} at full open. Operating point 60 percent open.	
Balanced poppet	$\frac{1.1\,V}{Q_{max}(100/PB)}$	$\frac{1.3\,V}{Q_{max}(100/PB)}$	Valve sized at 50 percent open.	

TABLE III

Proportional band settings for minimum vessel volume.

Valve Type	Vertical tank	Horizontal tank	Comments
Linear	$\frac{66\,Q_{max}}{\Delta Q_{in}}$	$\frac{57\,Q_{max}}{\Delta Q_{in}}$	The percent proportional band settings at the left are those required for the minimum surge vessel size using proportional plus reset controller action. For a specified surge reduction factor and input disturbance the minimum vessel size is computed from Equation 6. The controller reset time constant is computed from Equation 7 and set by the controller knob.
Equal-percentage	$\frac{163\,Q_{max}}{\Delta Q_{in}}$	$\frac{140\,Q_{max}}{\Delta Q_{in}}$	
Needle	$\frac{125\,Q_{max}}{\Delta Q_{in}}$	$\frac{114\,Q_{max}}{\Delta Q_{in}}$	
Balanced poppet	$\frac{59\,Q_{max}}{\Delta Q_{in}}$	$\frac{50\,Q_{max}}{\Delta Q_{in}}$	

Reset time constant is set at the controller knob.

Using a wide-band proportional plus automatic reset controller leads to a considerable decrease in vessel size over that required when using only proportional control. As an example of optimum vessel sizing, consider—as in the case of proportional control only—that

$$Q_{max} = 20 \text{ cfm}$$
$$\Delta Q_{in} = 2 \text{ cfm}$$
$$(dQ_{out})_{max} = 0.1 \text{ cfm/min}$$

Then, using Equation 6 the optimum volume is:

$$V = \frac{1.1(\Delta Q_{in})^2}{(dQ_{out})_{max}} = \frac{1.1 \times 2^2}{0.1} = 44 \text{ cu ft.}$$

The required proportional band and reset time constant for this example of optimum tank sizing are:

$$PB = \frac{66 Q_{max}}{\Delta Q_{in}} = \frac{66 \times 20}{2} = 660 \text{ percent}$$

$$\tau_R = 2.86 RF = \frac{2.86\, \Delta Q_{in}}{(dQ_{out})_{max}} = \frac{2.86 \times 2}{0.1} = 57 \text{ min/repeat}$$

As seen from this example, the volume required (44 cu ft) using a wideband controller with automatic reset is much less than the volume required (406 cu ft) using 100 percent proportional band control only. A controller having a proportional band from 0 to 1,000 percent and a reset time constant from 0.4 to 100 min/repeat will normally be adequate for achieving the desired system time constant and minimum vessel size regardless of the vessel-valve configuration. This type of controller is often referred to as an averaging level controller. Often, limit stops are incorporated to prevent over- or underflooding the surge vessel.

With the proportional band limited to 100 percent, the surge effectiveness is very dependent on the selection of valve type and vessel position as can be seen from the differing numerical constants of the entries in Table II. The larger the constant, the better the surge effectiveness. The best surge effectiveness for all operating regions is achieved with a horizontal cylindrical tank and a linear control valve. Surge effectiveness varies considerably with valve selection, the linear valve being far superior to the more common equal percentage type.

Surge effectiveness using the averaging level controller is essentially independent of valve selection or vessel position. These system nonlinearities are compensated for by the averaging level controller's wide proportional band.

With proportional control the outflow never overshoots its final value in recovering from a disturbance. With averaging level control however, the outflow overshoots the final value by 0.17 ΔQ_{in}. Ordinarily this is not serious, but the overshoot could become intolerable, for example, if the surge control system feeds a column already near its flooding point.

The relative surge effectiveness using the averaging level controller is always better than that achieved with proportional control. The increase in effectiveness depends on the ratio of the expected step magnitude to the maximum throughput, a ratio always assumed less than unity. For the same tank volume, the maximum outflow rate of change with the averaging level controller will be $\Delta Q_{in}/Q_{max}$ times as great as that from proportional control alone. In terms of the reduction factor:

$$RF_{prop\ plus\ reset} = \frac{RF_{prop}}{\frac{1.1\, \Delta Q_{in}}{Q_{max}}}$$

For normal values of $\Delta Q_{in}/Q_{max}$ from 0.05 to 0.15 the averaging level controller gives about five to twenty times the surge effectiveness for the same volume compared with straight proportional control.

Conversely for the same reduction factor, the averaging level controller requires a volume normally about one-fifth to one-twentieth the volume required with proportional control. The averaging level controller can always achieve the same surge effectiveness with less volume; however, its advantage decreases as $\Delta Q_{in}/Q_{max}$ gets larger. A good rule is to consider using the averaging level controller whenever the ratio $\Delta Q_{in}/Q_{max}$ is less than 0.5.

Economic benefits

The choice between a relatively expensive averaging level controller or a less expensive float-type controller will probably be dictated by economic considerations. Averaging level control normally requires, in addition to the proportional plus reset controller, a differential pressure cell or float level transmitter and a valve positioner. The cost difference of approximately \$750 must be justified by the smaller vessel size, reduced holdup time, reduced inventory storage, and other considerations.

On the basis of reduced vessel size only, the cost difference will be relatively easy to justify if the vessel is made of such special materials as glass-coated steel or stainless steel. Assume, for example, a 1,000-gal tank with averaging level control. The installed cost of a 1,000-gal steel tank is \$1,200, of a 100-gal one, \$500. Thus, the reduced tank size just about pays for the extra instrumentation. However, a savings will arise if the tank is made of stainless steel. A 1,000-gal stainless tank is about \$2,550, a 100-gal one, about \$800. The \$1,750 difference pays for the extra instrumentation and saves an additional \$1,000 through the use of a controller with wide proportional band and reset action.

Very often a flow controller is used to control the outflow from the surge vessel, with the flow controller setpoint being reset by the level controller. This cascade control method of accomplishing smooth outflow is common when wide pressure variations are expected across the control valve. However, cascade control offers no advantage over the averaging level controller when the pressure drop variation is 75 to 110 percent of nominal.

Thyratron Circuits for Solenoids and DC Loads

Ac solenoids and such dc loads as magnetic clutches and brakes can be "forced" to high response with xenon thyratrons and simple circuitry. Here are some circuits and practical information about their capabilities

FRANK MacPHERSON, Electrons, Inc.

SWITCHING SOLENOIDS

Switching of ac solenoids with a pair of xenon thyratrons forces fast solenoid response from low energy control signals. The grids can be controlled by microswitch, punched card, punched tape, or magnetic logic units connected directly in the grid circuits. High speeds can be realized for critically timed operations with no preamplification of the control signal. In a typical circuit (Figure 1) two EL C16J thyratrons connected in inverse parallel may control an ac load of 112 amp rms at low duty cycle or 40 amp rms continuously (2.22 × [average current rating for one thyratron]).

Design data

FIG. 1. Two EL C3J xenon thyratrons connected in inverse parallel can produce an overall amplifier and solenoid response of 5 millisec in a solenoid of ¼-in. stroke by switching at a voltage 2.5 times the rating of the solenoid.

FIG. 2. If the desired solenoid response can be 15 millisec or more, an ac solenoid may be even more simply controlled with a single thyratron as shown.

FIG. 1

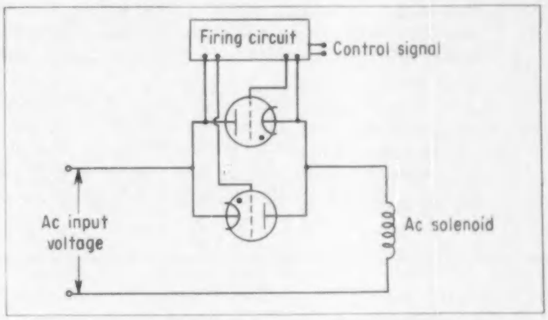


FIG. 2

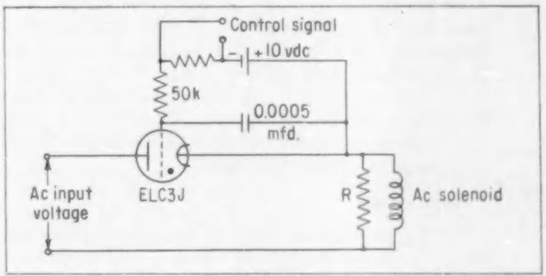


FIG. 3

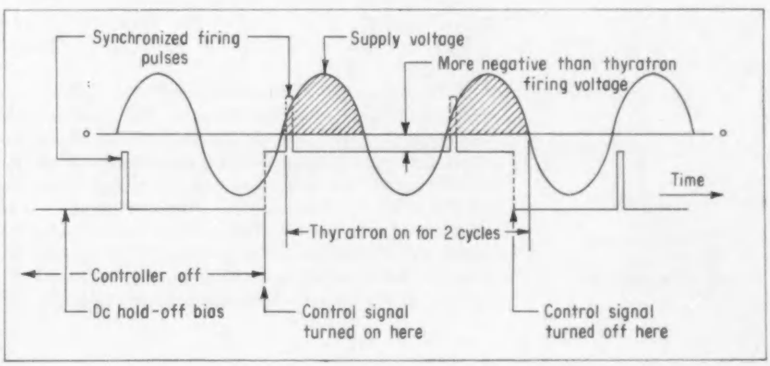


FIG. 3. Pulse-type firing signals synchronized with the anode voltage will assure the same pull-in force for each operation of the single thyratron circuit in Figure 2 regardless of when the control signal is applied.
Note that the thyratron will turn on only when the combination of the control voltage and pulse exceeds the firing voltage (shown as 0).

FIG. 4A

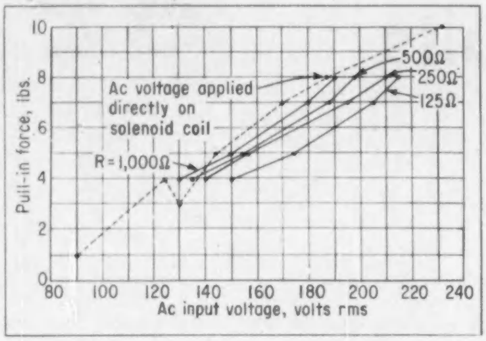


FIG. 4B

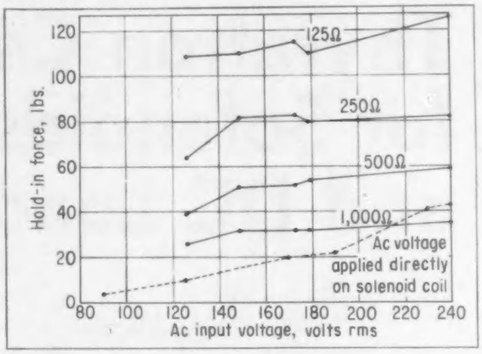


FIG. 4. In Figure 2 resistor R prevents chatter of the solenoid. Pull-in and holding force vary with R as shown. The maximum value of R is limited to that which allows continuous current in the solenoid coil. Its minimum value is set by the heat dissipation rating of the solenoid coil for the particular duty cycle used.

In general, high duty cycle operation or continuous energization of the ac solenoid will demand a higher value of shunt resistance R and it may also dictate an input ac voltage less than the solenoid rating. (The curves shown were measured on an ac solenoid with an input voltage rating of 230 volts. The input voltage may be increased or decreased to provide additional circuit design flexibility.) Inrush current during the first cycle of operation measured with a calibrated oscilloscope should be no greater than the thyratron's continuously recurring peak current rating (not the fault current rating).

Note that for a given input voltage the pull-in force decreases as R is decreased, while the hold-in force changes in the opposite direction. Thus, pull-in characteristics are sacrificed to some extent to control chatter, but holding force improves.

SWITCHING DC LOADS

Load current in typical fast acting dc magnetic clutches and brakes can be forced to build up in less than two cycles of the supply frequency by simple thyratron circuits that provide switching and rectification of load current within a single element (thus replacing a relay and a separate rectifier). Control power can be only milliwatts. On turn-off, automatic demagnetization of the load eliminates annoying clutch or brake stickiness.

Design data

FIG. 5. The simplest circuit for dc loads adds capacitor C to circuit of Figure 2. If an anode transformer is used, it must be capable of passing the dc component of current without saturating as well as the rms current due to the capacitor charging current on every cycle. If, for example, the load is a 90 vdc clutch or brake, this circuit may be supplied directly from a 240 vac line. The values shown are typical.

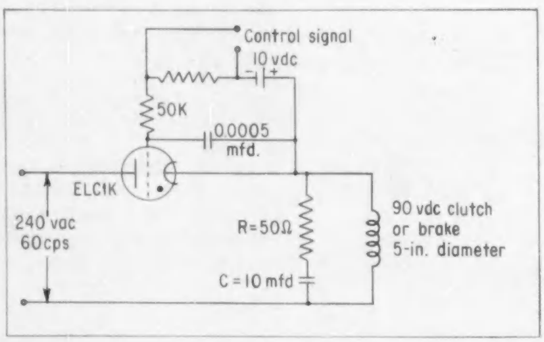


FIG. 5

FIG. 6. The capacitor C in Figure 5 performs three functions: 1) it charges each cycle to the peak value of the ac sine wave (or higher if line inductance is present) and so provides a high forcing voltage that causes fast load current buildup; 2) it supports the continuity of load current during each negative half cycle; and 3) on turn-off, the load current reverses through the capacitor momentarily, thus providing a desirable demagnetization of clutches or brakes.

FIG. 7. Both the peak inverse voltage and the peak forward voltage applied to the thyratron in Figure 5 may exceed the peak value of the input voltage and depend on the parameters of the resonant circuit R, L, and C.

Since capacitor C will discharge and recharge to a reversed polarity on each cycle, the peak inverse and peak forward voltage ratings of the thyratron must be at least equal to the maximum sum of the simultaneous instantaneous supply voltage and capacitor voltage. The actual transient voltage is best measured with an oscilloscope connected directly across the thyratron. The value of C is selected to provide the required dc voltage and continuous load current at the steady-state grid and firing angle.

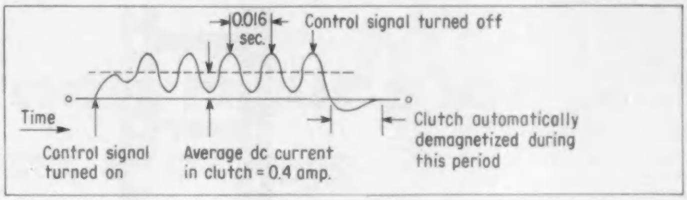


FIG. 6

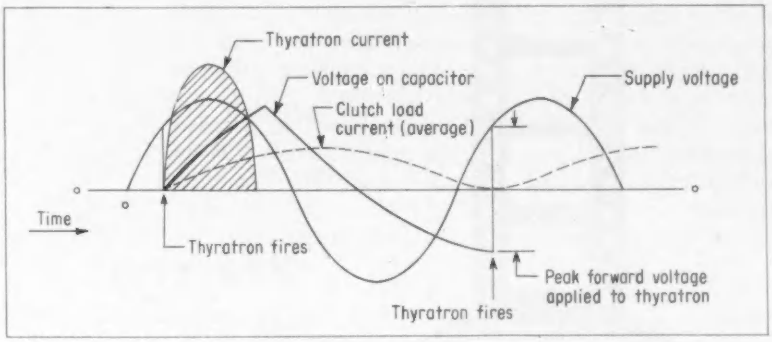


FIG. 7

The resistor R limits the peak current through the thyratron. The approximate value is equal to PFV/I_p; i.e., R equals the peak forward voltage imposed on the thyratron divided by the continuously recurring peak current rating of the thyratron (not the fault current rating).

FIG. 8. If the control signal in Figure 5 should appear on the grid during the time the anode voltage is negative, there will be a maximum inherent one-half cycle delay since the circuit is half-wave. The full-wave rectified anode voltage eliminates this delay by making the anode of the thyratron positive whenever the control signal occurs. The equivalent load circuit impedance comprising R, L, and C must be resistive or slightly capacitive to allow the thyratron time to deionize.

FIG. 9. If speed of response is not critical, this circuit provides smooth power from full off to full on or on-off step control for magnetic clutches and brakes and other electromagnetic power supplies.

The dc average current ratings of the thyratron and diode D in this circuit should be equal since both will carry essentially the same average dc current when the thyratron is full on. Thus, a 1-amp thyratron and a 1-amp diode D will control a continuous load current of 2 amp.

The peak inverse voltage applied to the thyratron is insignificant in this circuit but the peak forward voltage rating of the thyratron must be greater than $\sqrt{2}E_{rms}$, plus allowances if the grid firing signal is delayed beyond 90 deg. Diode D may be either a tube or semiconductor rectifier and must withstand a peak inverse voltage of $\sqrt{2}E_{rms}$, plus allowances for anticipated high line voltage. The maximum dc output voltage is about $(E_{rms}/2.2)$ — 10 volts.

Load current buildup time may be shortened by increasing the supply voltage E_{rms} (limited by the peak forward voltage rating of the thyratron) and retarding the grid firing angle after current buildup to limit the load current to steady-state ratings.

On turn-off, current in the load decays with the time constant in the "back rectifier loop", which is simply L/R_{total}. If R_2 is made larger, the time constant on turn-off, $L/(R_1 + R_2)$, is shortened and the system response is improved. E_{rms} may be increased to provide the required dc load voltage for an increased value of R_2. The maximum value of R_2 is therefore limited by the supply voltage and by the required continuous load current. Where response on turn-off is not critical, R_2 is omitted entirely.

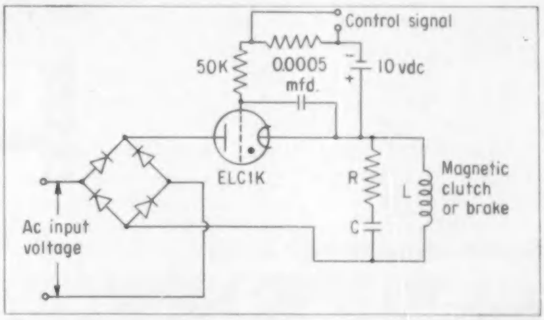


FIG. 8

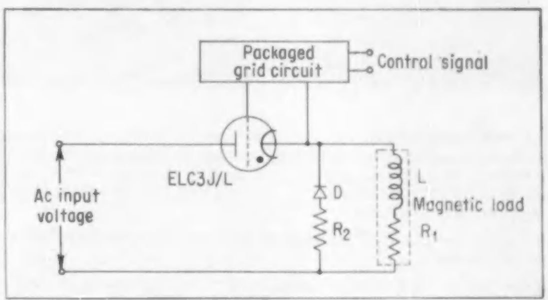
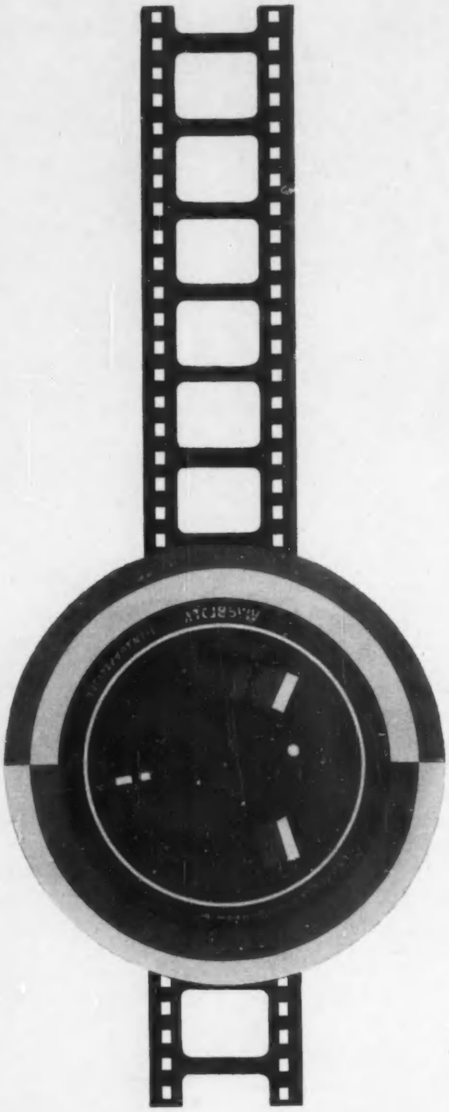


FIG. 9



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Characteristics of Digital Codes

THE GIST: With the increased use of digital techniques in various data handling and transmission systems, the control engineer is often confronted with the problem of choosing a suitable digital code for a particular application. Alternately, he may be constrained to use a specified code because of conditions out of his control, such as existing equipment. Or he may have to deal with the problem of converting from one code to another. This article defines the more important properties of digital codes that affect their selection and then presents certain specific codes currently used in computing, data handling, and data transmission systems.

LEO ROSEN, Anderson-Nichols & Co.

Digital codes have a number of practical properties which can be compared to the requirements of any particular data handling application. Which of these properties are the criteria for code selection depends on the application. Such criteria are often conflicting in real problems, and compromises must be made to select the "best" code.

The properties for consideration are:

1. *Compatibility*—the adaptability of a code to transmission over available or standard facilities. Also, the easy convertibility into other standard codes with which it may be used.
2. *Economy*—the ratio of the number of characters to be coded to the maximum number available with the code. For example, binary coded decimal using four bits provides 16 possible characters but uses only ten of them.
3. *Error checking*—the integral means for detecting transmission errors. For example, the 2-out-of-5 numeric code requires that two and only two of the five bits used be 1's, or an error is indicated. An alternative method wherein an extra bit is added for parity or check has the advantage of economy because the error check can be used when the probability of error is high and omitted under good signal to noise conditions. The extra bit makes the total number of 1's in the code character even for "even parity" or odd for "odd parity".
4. *Error correction*—the inclusion of means for determining the correct code when some of its elements are in error—implies error checking.
5. *Transmittability*—the ability of standard electronic and mechanical elements and automatic communication equipment to handle the code under various signal to noise ratios. For example, a code with a variable number of elements such as Morse presents technical problems in automatic interpretation not encountered in a fixed length code. Only fixed length codes are discussed in this article.
6. *Nonambiguity*—the property that any character can be recognized uniquely without reference to preceding characters or the spatial position of a character. In a code such as Baudot-teletypewriter in which a character can determine the significance of later characters, sorting into orders (alphabetic or numeric sequences) is difficult. Such codes have an economy advantage, however, in that fewer bits are needed to designate a character.
7. *Order*—the arrangement of characters in an ordered sequence (numerics in binary order and alphabetic characters in numeric order) to facilitate and simplify sorting.
8. *Interpretability*—a sensible (i.e., visual, aural, etc.) arrangement of elements to help a human operator interpret a code. Variable length codes are better in this respect than the fixed length codes discussed here.
9. *Contiguity*—the unit distance characteristic required by many analog to digital conversion techniques. Adjacent codes differ only by one bit and are therefore free from error even when read during a carry or change in higher order significant figures (see Table 1).
10. *Logical construction*—a simple logical property that determines the type of characters which a particular code represents. For example, the first two bits can tell whether a character is numeric or alphabetic.
11. *Easy manipulation*—a property that simplifies mathematical computation or other manipulations. For example, computing equipment is simpler with excess three binary coded decimal than for pure binary coded decimal.

Some specific digital codes in current use are illustrated and discussed in the following pages.

TABLE 1

Several of the codes developed from the pure binary form. Binary coded decimal is used in data handling where the need for simple conversion (input and output) to decimal form outweighs the economy of the pure binary form. Thus, a 20-bit binary code expresses values up to 2^{20} or about 10^6, while in binary coded decimal, since four bits are needed for each decimal, the range of values is only 10^5. The conversion from a 20-bit binary number to decimal (or vice versa) requires a fairly extensive routine, while the conversion from BCD to decimal proceeds on a simple digit by digit basis.

The excess three binary coded decimal is similar to BCD but the range of decimal values starts at binary 1100 (3) and ends at 0011 (12). This code simplifies some of the circuitry used in the arithmetic section of computers and avoids an all-0 number (zero in BCD).

The unit distance codes prevent ambiguous readings in analog to digital converters. As an example, in shaft position converters that use a segmented ring and brush for each digit, an unambiguous correct reading results when the brushes are positioned in the center of each segment, e.g., 0011 (3). But when the input shaft moves slightly, the third brush may pick up its next contact before the first and second brushes change, due to normal mechanical inaccuracies. In pure binary coding the output would read 0111 (7) and it should read 0100 (4). This is not possible in unit distance codes since one bit changes for each unit distance.

Conversion from the Gray unit distance code to decimal requires extensive manipulation. The Giannini Datex code simplifies this conversion problem by writing the (binary coded) decimals also in a unit distance code, thus—0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 19, 18, 17, 16, 15, 14, 13, 12, 11, 10, 20, 21, 22, etc. The binary code is so chosen that the nines complement of a number results merely by inverting the fourth bit, e.g., 1100 (1) and 1101 (8). Therefore if the converted Datex BCD "tens" digit is even, the "units" digit is converted; while if the "tens" digit is odd, the nines complement is converted. Thus 0100, 1100 in Datex is simply 21 in decimal, while 1100, 0011 (15) becomes 1100, 0010 or 14 in decimal, since the "tens" digit is odd.

The ring type of code provides error checking as well as unit distance. A one-bit error in the code shown gives either the adjacent magnitude or an impossible code. If used in an analog to digital converter, only one contact ring is needed since all four brushes can read the same ring. The code shown is not as economical as pure binary, since for 4 bits its range is only eight. Ring codes can be written with 2^N-1 discrete values if error checking is not required and the complexity of the conversion to pure binary or decimal is not a limitation. (N is the number of bits.)

BASIC BINARY CODES

PURE BINARY

BIT VALUE

16	8	4	2	1	
	0	0	0	0	0
	0	0	0	1	1
	0	0	1	0	2
	0	0	1	1	3
	0	1	0	0	4
	0	1	0	1	5
	0	1	1	0	6
	0	1	1	1	7
	1	0	0	0	8
	1	0	0	1	9
	1	0	1	0	10
	1	0	1	1	11
	1	1	0	0	12
	1	1	0	1	13
	1	1	1	0	14
	1	1	1	1	15
1	0	0	0	0	16
1	0	0	0	1	17
				ETC.	ETC.

NO CODE LIMIT ON NUMBER OF BINARY DIGITS (BITS)

4-BIT BINARY CODED DECIMAL

0	0	0	0	0
0	0	0	1	1
0	0	1	0	2
0	0	1	1	3
0	1	0	0	4
0	1	0	1	5
0	1	1	0	6
0	1	1	1	7
1	0	0	0	8
1	0	0	1	9
1	0	1	0	×
1	0	1	1	×
1	1	0	0	×
1	1	0	1	×
1	1	1	0	×
1	1	1	1	×

MAY BE USED FOR OTHER CHARACTERS

4-BIT LIMIT

EXCESS THREE BINARY CODED DECIMAL

0	0	0	0	×
0	0	0	1	×
0	0	1	0	×
0	0	1	1	0
0	1	0	0	1
0	1	0	1	2
0	1	1	0	3
0	1	1	1	4
1	0	0	0	5
1	0	0	1	6
1	0	1	0	7
1	0	1	1	8
1	1	0	0	9
1	1	0	1	×
1	1	1	0	×
1	1	1	1	×

4-BIT LIMIT

UNIT DISTANCE CODES

GRAY CODE

BIT POSITION

4	3	2	1	
0	0	0	0	0
0	0	0	1	1
0	0	1	1	2
0	0	1	0	3
0	1	1	0	4
0	1	1	1	5
0	1	0	1	6
0	1	0	0	7
1	1	0	0	8
1	1	0	1	9
1	1	1	1	10
1	1	1	0	11
1	0	1	0	12
1	0	1	1	13
1	0	0	1	14
1	0	0	0	15

GIANNINI DATEX (BCD)

4	3	2	1	
0	0	0	1	0
0	0	1	1	1
0	0	1	0	2
0	1	1	0	3
0	1	0	0	4
1	1	0	0	5
1	1	1	0	6
1	0	1	0	7
1	0	1	1	8
1	0	0	1	9

RING TYPE (4-BIT ERROR CHECKING)

4	3	2	1	
0	0	0	0	0
0	0	0	1	1
0	0	1	1	2
0	1	1	1	3
1	1	1	1	4
1	1	1	0	5
1	1	0	0	6
1	0	0	0	7

CODE FORMS A RING:

$\underbrace{0\ 0\ 0\ 0}_{0}\ 1\ 1\ 1\ 1$ — 1, 2, ETC.

COMPUTER CODES

IBM 705 CODE (7 BITS)

CONSTRUCTION: 0 PARITY (EVEN) | 0 0 ZONE | 0 0 0 0 DETAIL (4-BIT BCD)

ZONE 00, CARD –

PARITY	ZONE		DETAIL (BCD)				CHARACTER	CARD CODE
0	0	0	0	0	0	0	DRUM MARK	NONE
1	0	0	0	0	0	1	1	1
1	0	0	0	0	1	0	2	2
0	0	0	0	0	1	1	3	3
1	0	0	0	1	0	0	4	4
0	0	0	0	1	0	1	5	5
0	0	0	0	1	1	0	6	6
1	0	0	0	1	1	1	7	7
1	0	0	1	0	0	0	8	8
0	0	0	1	0	0	1	9	9
0	0	0	1	0	1	0	0	0
1	0	0	1	0	1	1	#	3-8
0	0	0	1	1	0	0	@	4-8
1	0	0	1	1	0	1	N. U.	
1	0	0	1	1	1	0	N. U.	
0	0	0	1	1	1	1	TAPE MARK	NONE

ZONE 01, CARD 0

PARITY	ZONE		DETAIL (BCD)				CHARACTER	CARD CODE
1	0	1	0	0	0	0	BLANK	NONE
0	0	1	0	0	0	1	/	0-1
0	0	1	0	0	1	0	S	0-2
1	0	1	0	0	1	1	T	0-3
0	0	1	0	1	0	0	U	0-4
1	0	1	0	1	0	1	V	0-5
1	0	1	0	1	1	0	W	0-6
0	0	1	0	1	1	1	X	0-7
0	0	1	1	0	0	0	Y	0-8
1	0	1	1	0	0	1	Z	0-9
1	0	1	1	0	1	0	‡	0-2-8
0	0	1	1	0	1	1	,	0-3-8
1	0	1	1	1	0	0	%	0-4-8
0	0	1	1	1	0	1	N. U.	
0	0	1	1	1	1	0	N. U.	
1	0	1	1	1	1	1	N. U.	

ZONE 10, CARD 11

PARITY	ZONE		DETAIL (BCD)				CHARACTER	CARD CODE
1	1	0	0	0	0	0	—	11
0	1	0	0	0	0	1	J	11-1
0	1	0	0	0	1	0	K	11-2
1	1	0	0	0	1	1	L	11-3
0	1	0	0	1	0	0	M	11-4
1	1	0	0	1	0	1	N	11-5
1	1	0	0	1	1	0	O	11-6
0	1	0	0	1	1	1	P	11-7
0	1	0	1	0	0	0	Q	11-8
1	1	0	1	0	0	1	R	11-9
1	1	0	1	0	1	0	ō	11-0
0	1	0	1	0	1	1	$	11-3-8
1	1	0	1	1	0	0	*	11-4-8
0	1	0	1	1	0	1	N. U.	N. U.
0	1	0	1	1	1	0	N. U.	
1	1	0	1	1	1	1	N. U.	

ZONE 11, CARD 12

PARITY	ZONE		DETAIL (BCD)				CHARACTER	CARD CODE
0	1	1	0	0	0	0	&	12
1	1	1	0	0	0	1	A	12-1
1	1	1	0	0	1	0	B	12-2
0	1	1	0	0	1	1	C	12-3
1	1	1	0	1	0	0	D	12-4
0	1	1	0	1	0	1	E	12-5
0	1	1	0	1	1	0	F	12-6
1	1	1	0	1	1	1	G	12-7
1	1	1	1	0	0	0	H	12-8
0	1	1	1	0	0	1	I	12-9
0	1	1	1	0	1	0	ꝺ	12-0
1	1	1	1	0	1	1	•	12-3-8
0	1	1	1	1	0	0	▭	12-4-8
1	1	1	1	1	0	1	N. U.	
1	1	1	1	1	1	0	N. U.	
0	1	1	1	1	1	1	‡	12-5-8

DATAMATIC CODE (6 BITS) (MINNEAPOLIS-HONEYWELL)

CONSTRUCTION: 0 0 ZONE | 0 0 0 0 DETAIL (BCD)

SIX-BIT BCD

ZONE 00	ZONE 01	ZONE 10	ZONE 11	DETAIL (BCD)			
0	SPACE	—	&	0	0	0	0
1	A	J	/	0	0	0	1
2	B	K	S	0	0	1	0
3	C	L	T	0	0	1	1
4	D	M	U	0	1	0	0
5	E	N	V	0	1	0	1
6	F	O	W	0	1	1	0
7	G	P	X	0	1	1	1
8	H	Q	Y	1	0	0	0
9	I	R	Z	1	0	0	1
'	Cr	=	:	1	0	1	0
#	.	$	,	1	0	1	1
@	▭	*	%	1	1	0	0
+	(	¢	½	1	1	0	1
N. U.	)	N. U.	N. U.	1	1	1	0
N. U.	N. U.	N. U.	N. U.	1	1	1	1

HEXADECIMAL

CHARACTER		DETAIL (BCD)			
0		0	0	0	0
1		0	0	0	1
2		0	0	1	0
3		0	0	1	1
4		0	1	0	0
5		0	1	0	1
6		0	1	1	0
7		0	1	1	1
8		1	0	0	0
9		1	0	0	1
10	B	1	0	1	0
11	C	1	0	1	1
12	D	1	1	0	0
13	E	1	1	0	1
14	F	1	1	1	0
15	G	1	1	1	1

TABLE 3

Except for the lack of parity and the assignment of special characters, the Datamatic 1000 (Minneapolis-Honeywell) code is identical to the IBM 705 code. The type of error checking used in the Datamatic 1000 replaces the need for parity checking. Instead, a transfer weight check is used in which each bit position is assigned a weight (1 = 1, 2 = 2, 3 = 4, 4 = 8, and the weight count is sent as a separate character ranging from 0 to 8, but 0 is sent as 9). The Datamatic 1000 also uses the hexadecimal code (without the two zone characters), when only numbers are involved, for a significant improvement in machine speed since only four bits need be handled per decimal digit.

TABLE 2

The IBM 705 computer code uses 7 bits—one for parity, two for "zone" and four for "detail". The zone bits determine whether or not the character is a number. Detail bits are straight BCD. The characters are arranged in ordered sequence to simplify alphabetic sorting. The code is nonambiguous, and the party check can be omitted if not required. It is compatible with the IBM punched card code (Table 13A).

UNIVAC II CODE (7 BITS–EXCESS THREE) (SPERRY RAND CORP.)

CONSTRUCTION: 0 PARITY (ODD) | 0 0 ZONE | 0 0 0 0 DETAIL (XS-3, BCD)

ZONE 00	ZONE 01	ZONE 10	ZONE 11	DETAIL (XS-3)
ι	r	t	Σ	0 0 0 0
Δ	,	"	β	0 0 0 1
—	·	[	:	0 0 1 0
0	;	)	+	0 0 1 1
1	A	J	/	0 1 0 0
2	B	K	S	0 1 0 1
3	C	L	T	0 1 1 0
4	D	M	U	0 1 1 1
5	E	N	V	1 0 0 0
6	F	O	W	1 0 0 1
7	G	P	X	1 0 1 0
8	H	Q	Y	1 0 1 1
9	I	R	Z	1 1 0 0
'	#	$	%	1 1 0 1
&	¢	*	=	1 1 1 0
(	@	?	N.U.	1 1 1 1

UNIVAC TAPE

TABLE 4

The UNIVAC II code also exhibits a lot of similarity to the IBM 705 code except that all of the values are excess three rather than binary coded decimal. Parity is opposite from the 705. Numeric sorting is possible, and conversion to punched cards is simple.

RCA 501-2-3 CODE (7 BITS) (RADIO CORP. OF AMERICA)

CONSTRUCTION: 0 PARITY EVEN (PAPER TAPE) ODD (MAGNETIC TAPE) | 0 0 ZONE | 0 0 0 0 DETAIL (BCD)

ZONE 00	ZONE 01	ZONE 10	ZONE 11	DETAIL (BCD)
BLANK	PG. CHANGE	A	Q	0 0 0 0
SPACE	LINE SHIFT	B	R	0 0 0 1
*	/	C	S	0 0 1 0
(	0	D	T	0 0 1 1
)	1	E	U	0 1 0 0
"	2	F	V	0 1 0 1
:	3	G	W	0 1 1 0
$	4	H	X	0 1 1 1
%	5	I	Y	1 0 0 0
;	6	J	Z	1 0 0 1
&	7	K	END FILE	1 0 1 0
'	8	L	END DATA	1 0 1 1
—	9	M	ITEM SEPARATOR	1 1 0 0
*	,	N	END MSG.	1 1 0 1
·	#	O	START MSG.	1 1 1 0
CARR. SHIFT	CARR. NORM.	P	DELETE MSG.	1 1 1 1

TABLE 5

The RCA 501-2-3 code is also substantially similar to the 705 code except that the zone bits are differently assigned and numbers are in excess three BCD.

FIELDATA CODE (7 BITS PLUS CONTROL BIT) (U.S. ARMY SIGNAL CORPS)

Notes: N.A. = not assigned; M.D.A. = message data A; R.C.A. = remote control A; Tape, M = magnetic tape, P = paper tape

CONSTRUCTION: 0 PARITY (MAGNETIC TAPE, ODD; PAPER TAPE, EVEN) | 0 0 ZONE | 0 0 0 0 DETAIL (BCD) | 0 CONTROL

CONTROL BITS

DETAIL (BCD)	ZONE 00	M	P	ZONE 00	M	P	ZONE 01	M	P	ZONE 01	M	P
0 0 0 0	N.A.	0	0	MASTER SPACE	1	1	N.A.	0	0	K	1	1
0 0 0 1	BLANK	0	1	U.CASE	1	0	DIAL 8	0	1	L	1	0
0 0 1 0	N.A.	0	0	L.CASE	1	1	N.A.	0	0	M	1	1
0 0 1 1	DIAL 1	0	1	TAB.	1	0	DIAL 9	0	1	N	1	0
0 1 0 0	N.A.	0	0	CAR.RET.	1	1	N.A.	0	0	O	1	1
0 1 0 1	DIAL 2	0	1	SPACE	1	0	DIAL 0	0	1	P	1	0
0 1 1 0	N.A.	0	0	A	1	1	N.A.	0	0	Q	1	1
0 1 1 1	DIAL 3	0	1	B	1	0	START B	0	1	R	1	0
1 0 0 0	N.A.	0	0	C	1	1	N.A.	0	0	S	1	1
1 0 0 1	DIAL 4	0	1	D	1	0	M.D.A.	0	1	T	1	0
1 0 1 0	N.A.	0	0	E	1	1	N.A.	0	0	U	1	1
1 0 1 1	DIAL 5	0	1	F	1	0	M.D.B.	0	1	V	1	0
1 1 0 0	N.A.	0	0	G	1	1	N.A.	0	0	W	1	1
1 1 0 1	DIAL 6	0	1	H	1	0	M.D.C.	0	1	X	1	0
1 1 1 0	N.A.	0	0	I	1	1	N.A.	0	0	Y	1	1
1 1 1 1	DIAL 7	0	1	J	1	0	M.D.D.	0	1	Z	1	0

DETAIL (BCD)	ZONE 10	M	P	ZONE 10	M	P	ZONE 11	M	P	ZONE 11	M	P
0 0 0 0	N.A.	0	0	)	1	1	N.A.	0	0	0	1	1
0 0 0 1	R.C.A.	0	1	—	1	0	R.C.H.	0	1	1	1	0
0 0 1 0	N.A.	0	0	+	1	1	N.A.	0	0	2	1	1
0 0 1 1	R.C.B.	0	1	<	1	0	R.C.J.	0	1	3	1	0
0 1 0 0	N.A.	0	0	=	1	1	N.A.	0	0	4	1	1
0 1 0 1	R.C.C.	0	1	>	1	0	R.C.K.	0	1	5	1	0
0 1 1 0	N.A.	0	0	__	1	1	N.A.	0	0	6	1	1
0 1 1 1	R.C.D.	0	1	$	1	0	R.C.L.	0	1	7	1	0
1 0 0 0	N.A.	0	0	*	1	1	N.A.	0	0	8	1	1
1 0 0 1	END B	0	1	(	1	0	R.C.M.	0	1	9	1	0
1 0 1 0	N.A.	0	0	"	1	1	N.A.	0	0	'	1	1
1 0 1 1	R.C.E.	0	1	:	1	0	R.C.N.	0	1	;	1	0
1 1 0 0	N.A.	0	0	/	1	1	N.A.	0	0	?	1	1
1 1 0 1	R.C.F.	0	1	!	1	0	R.C.P.	0	1	.	1	0
1 1 1 0	N.A.	0	0	,	1	1	N.A.	0	0	SPECIAL	1	1
1 1 1 1	R.C.G. (STOP)	0	1	STOP	1	0	DELETE	0	1	BACK SPACE	1	0

TABLE 6

The Fieldata code to be used by the U. S. Army in field data processing illustrates an ingenious compromise in the selection of a code from conflicting criteria. Ignoring the control bit for the moment, the code uses parity for error checking, the zone determines the type of character, and the characters are ordered for easy sorting. Parity may be omitted for use internally in the computers and added if data is to be transmitted over a communication link. The code is unambiguous and economical. The addition of the eighth or control bit permits using the same code for an additional set of characters for remote control, yet within a particular machine such as a printer, the control bit may be omitted entirely. Conversion to punched cards is simple for numeric information, but not quite so easy for alphabetic.

DATATRON CODE (8 BITS) (BURROUGHS CORP)

CONSTRUCTION: 0 0 0 0 | 0 0 0 0 (4-BIT BCD FOR NUMERALS) (TWO 4-BIT BCD GROUPS FOR OTHER CHARACTERS)

CHARACTER	BCD 2	BCD 1	DECIMAL FORM
A	0 1 0 0	0 0 0 1	4 - 1
B	0 1 0 0	0 0 1 0	4 - 2
C	0 1 0 0	0 0 1 1	4 - 3
D	0 1 0 0	0 1 0 0	4 - 4
E	0 1 0 0	0 1 0 1	4 - 5
F	0 1 0 0	0 1 1 0	4 - 6
G	0 1 0 0	0 1 1 1	4 - 7
H	0 1 0 0	1 0 0 0	4 - 8
I	0 1 0 0	1 0 0 1	4 - 9
J	0 1 0 1	0 0 0 1	5 - 1
K	0 1 0 1	0 0 1 0	5 - 2
L	0 1 0 1	0 0 1 1	5 - 3
M	0 1 0 1	0 1 0 0	5 - 4
N	0 1 0 1	0 1 0 1	5 - 5
O	0 1 0 1	0 1 1 0	5 - 6
P	0 1 0 1	0 1 1 1	5 - 7
Q	0 1 0 1	1 0 0 0	5 - 8
R	0 1 0 1	1 0 0 1	5 - 9
S	0 1 1 0	0 0 1 0	6 - 2
T	0 1 1 0	0 0 1 1	6 - 3
U	0 1 1 0	0 1 0 0	6 - 4
V	0 1 1 0	0 1 0 1	6 - 5
W	0 1 1 0	0 1 1 0	6 - 6
X	0 1 1 0	0 1 1 1	6 - 7
Y	0 1 1 0	1 0 0 0	6 - 8
Z	0 1 1 0	1 0 0 1	6 - 9

CHARACTER	BCD 2	BCD 1	DECIMAL FORM
BLANK	0 0 0 0	0 0 0 0	0 - 0
·	0 0 0 0	0 0 1 1	0 - 3
▭	0 0 0 0	0 1 0 0	0 - 4
&	0 0 0 1	0 0 0 0	1 - 0
$	0 0 0 1	0 0 1 1	1 - 3
*	0 0 0 1	0 1 0 0	1 - 4
—	0 0 1 0	0 0 0 0	2 - 0
/	0 0 1 0	0 0 0 1	2 - 1
,	0 0 1 0	0 0 1 1	2 - 3
%	0 0 1 0	0 1 0 0	2 - 4
#	0 0 1 1	0 0 1 1	3 - 3
@	0 0 1 1	0 1 0 0	3 - 4
+0	0 1 0 0	0 0 0 0	4 - 0
−0	0 1 0 1	0 0 0 0	5 - 0
0	1 0 0 0		8 -
1	1 0 0 0	0 0 0 1	8 - 1
2	1 0 0 0	0 0 1 0	8 - 2
3	1 0 0 0	0 0 1 1	8 - 3
4	1 0 0 0	0 1 0 0	8 - 4
5	1 0 0 0	0 1 0 1	8 - 5
6	1 0 0 0	0 1 1 0	8 - 6
7	1 0 0 0	0 1 1 1	8 - 7
8	1 0 0 0	1 0 0 0	8 - 8
9	1 0 0 0	1 0 0 1	8 - 9
+	AT SIGN	TIME ONLY	1-0-9
—	AT SIGN	TIME ONLY	0-0-9

TABLE 7

The Datatron code again is basically binary coded decimal and numeric information is handled in this form. But two BCD characters are used for alphanumeric information. The code selection has been made to simplify conversion to the IBM punched card code (Table 13A). The efficiency of the code depends on the type of material being handled since 4 bits are needed for numerals, but 8 bits are needed for alphanumeric characters.

PAPER TAPE CODES

TABLE 8

The 5-unit Baudot paper tape code is probably the oldest and the most widespread of all the codes in use today. Since most of the world's printing telegraphy communication networks are committed to it, this criterion alone is often sufficient for its selection. It is ambiguous in that the case shift character determines the sense of all following characters, but it does have the economic advantage of using only 5 bits to designate characters after the case has been determined. Since the code is arbitrary (i.e., not ordered) conversion to computer codes must be on a tabular look-up basis and sorting into an ordererd sequence cannot be done on a numeric basis. In communications transmission this code is usually sent with the bits in sequence. The actual character designating bits may be preceded with synchronizing bits (start) of the same length and followed by a synchronizing bit (stop) whose duration is 1, 1.42, or 1.5 times that of the information bit.

TELETYPE-FLEXOWRITER CODES (5-BIT BAUDOT)

CHANNEL 1	CHANNEL 2	SPROCKET	CHANNEL 3	CHANNEL 4	CHANNEL 5	TELETYPE LOW. CASE	TELETYPE UP. CASE	FRIDEN FLEXOWRITER LETTERS	FRIDEN FLEXOWRITER 4 BANK FIGS.	FRIDEN FLEXOWRITER 3 BANK FIGS.
●	●	•				A	—	A	—	—
●		•		●	●	B	?	B	$	$
	●	•	●	●		C	:	C	NO PRINT	NO PRINT
●		•		●		D	$	D	TAB	TAB
●		•				E	3	E	3	3
●		•	●	●		F	!	F	NOT USED	,
	●	•		●	●	G	&	G	&	&
		•	●		●	H	£	H	NOT USED	(
	●	•	●			I	8	I	8	8
●	●	•		●		J	'	J	ERROR	ERROR
●	●	•	●	●		K	(	K	PRINT RESTORE	PRINT RESTORE
	●	•			●	L	)	L	NOT USED	)
		•	●	●	●	M	.	M	.	.
		•	●	●		N	,	N	,	,
		•		●	●	O	9	O	9	9
	●	•	●		●	P	0	P	0	0
●	●	•	●		●	Q	1	Q	1	1
	●	•		●		R	4	R	4	4
●		•	●			S	BELL	S	/	/
		•			●	T	5	T	5	5
●	●	•	●			U	7	U	7	7
	●	•	●	●	●	V	;	V	PUNCH OFF	PUNCH OFF
●	●	•			●	W	2	W	2	2
●		•	●	●	●	X	/	X	NOT USED	PUNCH ON 2
●		•	●		●	Y	6	Y	6	6
●		•			●	Z	"	Z	NOT USED	PUNCH ON 1
		•				BLANK	BLANK	STOP CODE	STOP CODE	STOP CODE
●	●	•	●	●	●	LETTERS	LETTERS	—	LETTERS	LETTERS
●	●	•		●	●	FIGURES	FIGURES	FIGURES	—	—
		•	●			SPACE	SPACE	SPACE	SPACE	SPACE
		•		●		CAR. RET.	CAR. RET.	CAR. RET.	CAR. RET.	CAR. RET.
	●	•				LINE FEED	LINE FEED	PUNCH ON 2 L.F.	PUNCH ON 1	LINE FEED

EIGHT-BIT ERROR DETECTING CODE (U.S. AIRFORCE)

	1	2	3	4	5	•	6	7	8
A	●	●				•	●	●	
B	●			●	●	•		●	
C		●	●	●		•		●	
D	●			●		•	●		●
E	●					•	●	●	●
F	●		●	●		•			●
G		●		●	●	•			●
H			●		●	•	●	●	
I		●	●			•	●		●
J	●	●		●		•		●	
K	●	●	●	●		•			
L		●			●	•	●		●
M			●	●	●	•		●	
N			●	●		•	●		●
O				●	●	•	●		●
P		●	●		●	•		●	
Q	●	●	●		●	•			
R		●		●		•	●		●
S	●		●			•		●	●
T					●	•	●	●	●
U	●	●	●			•	●		
V		●	●	●	●	•			
W	●	●			●	•			●
X	●		●	●	●	•			
Y	●		●		●	•		●	
Z	●				●	•		●	●
CAR. RET.				●		•	●	●	●
LINE FD.		●				•	●	●	●
SPACE			●			•			
SYNCH.	●	●	●	●	●	•	●	●	

	1	2	3	4	5	•	6	7	8
—	●	●	●			•		●	
?	●	●		●	●	•			
:		●			●	•	●	●	
$	●		●		●	•			●
3	●	●	●			•			●
!	●				●	•	●		●
&				●	●	•		●	●
MOTOR STOP		●	●	●		•	●		
8			●			•	●	●	●
'	●	●			●	•		●	
(	●				●	•	●	●	
)			●	●		•		●	●
.		●		●	●	•	●		
,			●		●	•	●		●
9			●	●	●	•			●
¢		●		●		•	●	●	
1	●			●		•	●	●	
4			●		●	•		●	●
BELL	●	●				•	●		●
5		●	●	●		•			●
7	●		●			•	●	●	
;				●	●	•	●	●	
2	●			●		•		●	●
/	●			●	●	•	●		
6	●	●		●		•	●		
"	●	●		●		•			●

	1	2	3	4	5	•	6	7	8
PHONE CALL	●		●			•	●		●
WHO R YOU	●	●				•		●	●
+			●	●	●	•	●		
= CLEAR		●		●	●	•		●	
←	●	●			●	•	●		
↖	●		●	●		•		●	
↑	●		●	●		•	●		
↗	●		●		●	•	●		
→			●	●		•	●	●	
↘		●	●		●	•	●		
↓		●			●	•		●	●
↙		●		●		•		●	●
⊕		●	●			•	●	●	
0	●			●	●	•			●
N.A.		●	●			•		●	●
N.A.		●	●		●	•			●

Note 1: Code must contain four 1's. Detected errors replaced by space.

Note 2: Channels 2 through 7 in letters are same as channels 7 through 2 in figures.

Note 3: N.A. = not assigned

TABLE 9

An eight-bit code derived from the standard Baudot code by the addition of error checking bits. In this code exactly 4 bits must be marking (1) and 4 bits must be spacing (0), a limitation which makes the code redundant since many of the 256 possible characters are not allowable. This code is easily converted into the standard Baudot and vice versa. While it is not ambiguous, it is not ordered, and conversion to computer codes must be on a tabular look-up basis.

SEVEN-BIT ERROR CHECKING CODE (MOORE CODE)

	1	2	3	•	4	5	6	7
A			●	•	●		●	
B			●	•	●			●
C	●			•	●	●		
D			●	•	●	●		
E		●	●	•	●			
F			●	•			●	●
G	●	●		•				●
H	●		●	•			●	
I	●	●	●	•				
J		●		•			●	●
K				•	●		●	●
L	●	●		•			●	
M	●		●	•				●
N	●		●	•		●		
O	●			•		●	●	
P	●			•	●		●	
Q				•	●	●		●
R	●	●		•		●		
S		●		•	●		●	
T	●			•		●		●
U		●	●	•				●
V	●			•	●			●
W		●		•		●		●
X			●	•		●	●	
Y			●	•		●		●
Z		●	●	•				●

	1	2	3	•	4	5	6	7
SPACE	●	●		•	●			
CAR. RET.	●			•			●	●
LINE FD.	●		●	•	●			
FIGS.		●		•		●	●	
LTRS.				•	●	●	●	
IDLE α		●		•	●			●
IDLE β		●		•	●	●		
REQUEST		●	●	•		●		
↔						●	●	●

Note: Code must contain three 1's or error is noted.

TABLE 10

A 3-out-of-7 error checking code which is redundant since many of the 128 possible characters are not allowable. The character assignment is not ordered, and conversion to other codes must be on a tabular basis.

DATATRON TYPEWRITER CODE

	1	2	3	•	4	5	6	7
A				•		●		
B	●			•		●	●	
C		●		•		●	●	
D	●	●		•		●	●	
E			●	•		●	●	
F	●		●	•		●	●	
G		●	●	•		●	●	
H	●	●	●	•		●	●	
I				•	●	●	●	
J	●			•	●	●	●	
K		●		•	●	●	●	
L		●	●	•	●	●		
M	●	●		•	●	●	●	
N			●	•	●	●	●	
O	●		●	•	●	●	●	
P		●	●	•	●	●	●	
Q	●	●	●	•	●	●	●	
R	●		●	•		●		
S		●		•		●		
T	●	●		•		●		
U		●		•	●		●	
V	●	●		•	●		●	
W			●	•	●		●	
X	●		●	•	●		●	
Y		●	●	•	●		●	
Z	●	●	●	•	●		●	

	1	2	3	•	4	5	6	7	FOLLOWING UPPER CASE SHIFT
0				•			●		)
1	●			•			●		½
2		●		•			●		&
3	●	●		•			●		/
4			●	•			●		$
5	●		●	•			●		%
6		●	●	•			●		?
7	●	●	●	•			●		!
8				•	●		●		*
9	●			•	●		●		(
+			●	•		●			=
−	●		●	•		●			—
'	●	●		•	●	●			"
;		●	●	•		●			:
TAB			●	•					
L.C. SHIFT	●	●	●	•	●				
U.C. SHIFT				•	●	●			
CAR. RET.	●		●	•					
COLOR SHIFT	●		●	•	●	●			
BACK SPACE	●			•					
DELETE				•				●	
SPACE			●	•	●	●			
STOP	●	●	●	•					

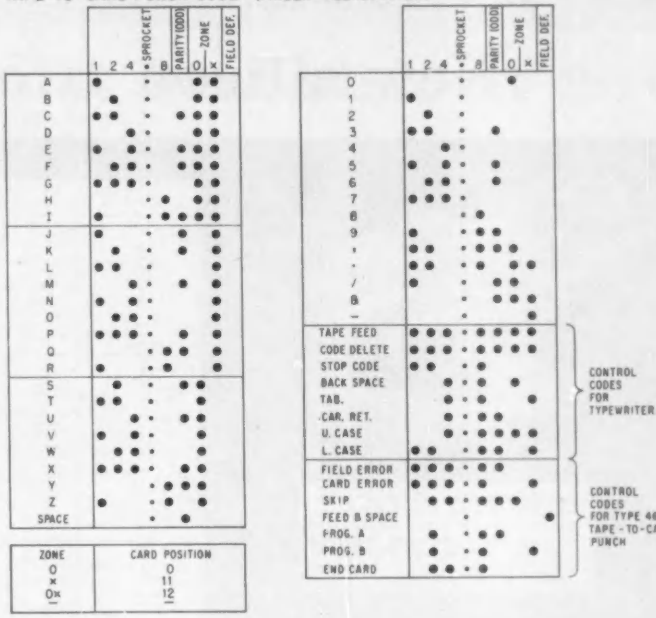
TABLE 12

The Datatron punched tape code (7 bits) designed to convert easily to the Datatron code (Table 7), a BCD form of the IBM card code. An additional code bit is required to control a typewriter.

TABLE 11

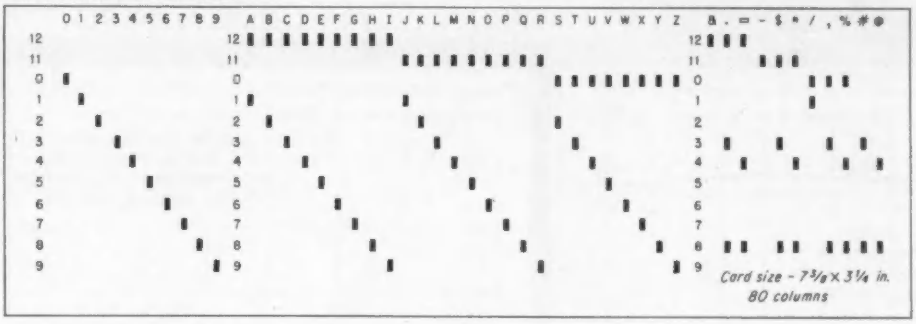
A punched tape code which has been chosen primarily for its compatibility with the IBM punched card coding. The channel values convert directly into the card punching, and card punch control signals are directly provided. A parity (check bit) is included and requires that the total number of holes be odd.

TAPE-TO-CARD-PUNCH CODE (FRIDEN-FLEXOWRITER)



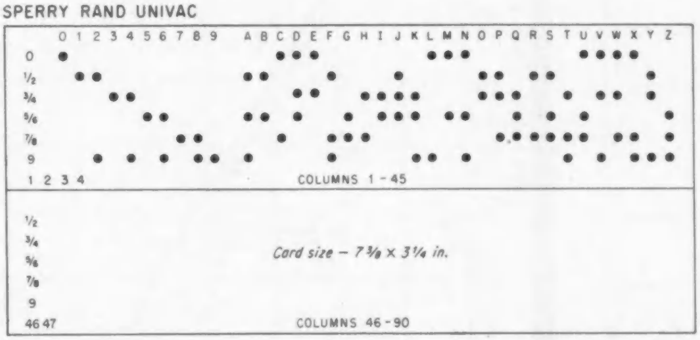
PUNCHED CARD CODES

IBM PUNCHED CARD CODES



A

SPERRY RAND UNIVAC



B

C SAMAS UNDERWOOD

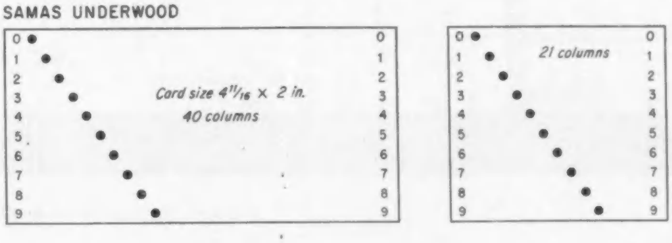


TABLE 13

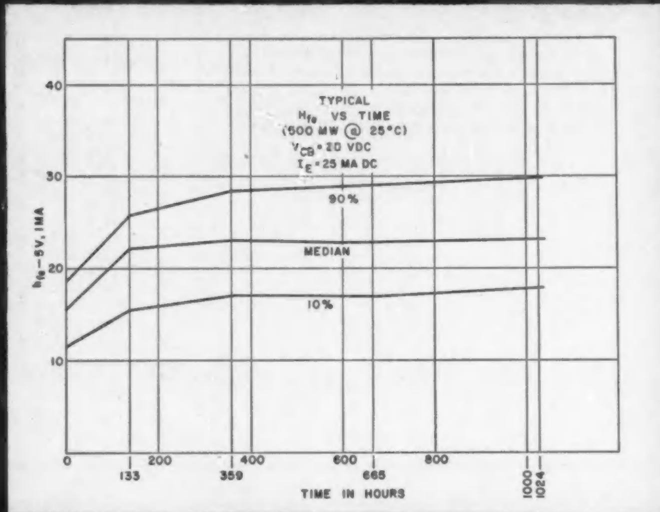
(A)—The format and code used in the standard IBM punched card is not susceptible to parity checking and is extremely uneconomical since only 47 of the 4096 (2^{12}) possible combinations are usually used. This code is easily interpreted by an operator since the numeric values can be read directly from the card and the alphabet is easily learned. The code is unambiguous and compatible with most of the computer codes described in this article.

(B)—The Sperry Rand punched cards provide 90 character positions as compared to the 81 characters possible on the IBM card. The numeric characters can be learned easily, but reading the alphabetic information is difficult. Conversion to other codes must be done on a tabular look-up basis. The code is unambiguous, and is not susceptible to effective parity error checking.

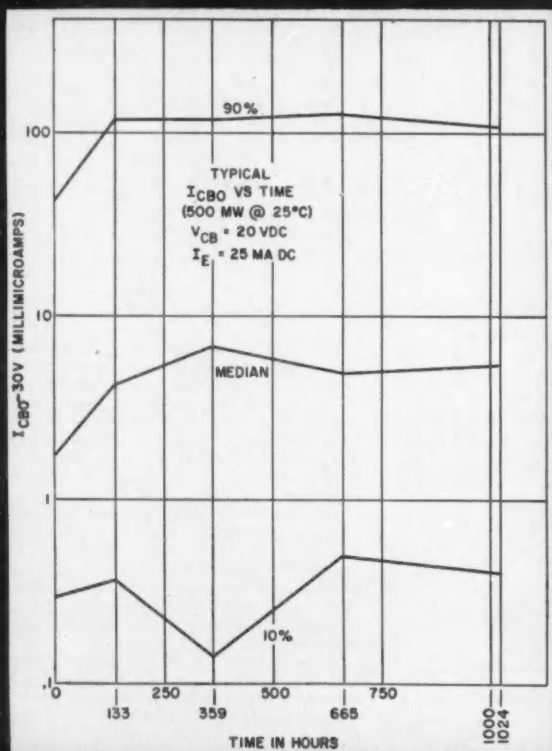
(C)—The two Underwood (Samas) type punched cards are smaller, 21 and 40 columns each, and provide for numeric information only. The code is directly readable and unambiguous.

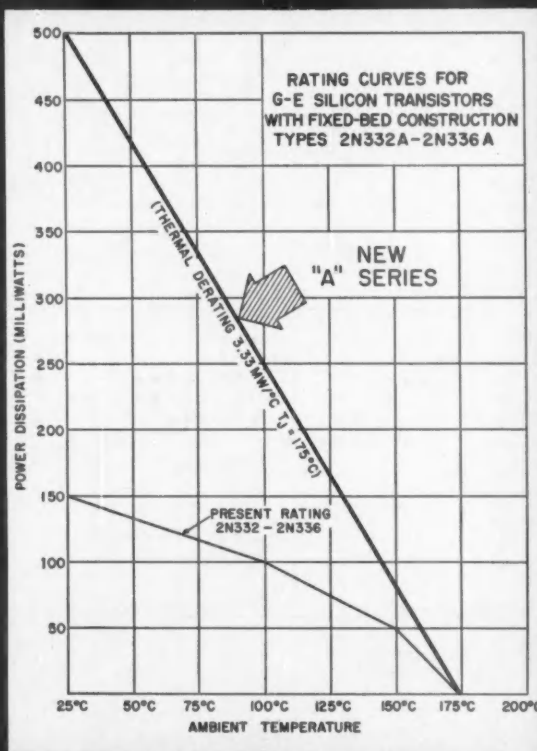
New silicon triodes dissipate

Greatly magnified photo of silicon transistor showing Fixed Bed Construction. All parts are firmly fastened, with no suspended parts except wire lead. Transistor reacts as a solid block in resisting shock and vibration. Power dissipation is inherently higher.



Power dissipation of the 2N332A-through-2N336A silicon transistors (see chart below) ranges from 500 mw at 25°C to 83 mw at 150°C without heat sink. Note also (see chart below, left) the extremely low I_{CBO} throughout 1000 hours of testing. Nearly 90% of units fall within 100 mμa. Beta spread (chart above) is stable out to 1000 hours.





500 mw without heat sink at 25°C

FIXED BED MOUNTED TRANSISTORS 2N332A-through-2N336A ALSO FEATURE: 4 VOLT V_{EB} . . . GUARANTEED 45 VOLT V_{CE} . . . .005 μa MAX. I_{CBO} AT 25°C AND 30 VOLTS . . . PHYSICAL AND ELECTRICAL STABILITY

The 2N332A-through-2N336A line of silicon NPN triodes is a new series of amplifier and switching transistors capable of much higher performance than ever before achieved.

Collector dissipation without heat sink is 500 mw at 25°C . . . 83 mw at 150°C. Since reliability is related to junction temperature, even those designs which do not require maximum-rated power may be enhanced greatly by this device series because of the wide safety-factor potential provided.

FOUR OTHER ADVANTAGES—Collector-to-emitter voltage is guaranteed at 45 volts. Collector leakage current is a maximum of 500 mμa at 30 volts and 25°C. Collector-to-emitter leakage current is 60 μa at 150°C. Minimum cutoff frequency is 2.5 mc, typical f_{ab} is 10 to 15 mc.

FIXED BED MOUNTING—Fixed Bed Mounting is an exclusive G-E construction technique which contributes to the extreme stability obtained by this series of transistors. Storage and operating tests have resulted in a performance rate of better than 99.2% after 1000 hours.

Besides the demonstrated electrical characteristics, General Electric's silicon transistors can absorb physical punishment far beyond normal specifications. All parts are solidly fixed together and react as a solid block in resisting shock and vibration. Test units have been fired from a shotgun, struck with a golf club and rattled freely in an auto hubcap for 700 miles—and worked afterward.

IMMEDIATELY AVAILABLE—All types are available now from warehouse stock. Call your General Electric Semiconductor Sales Representative for complete details on the "hot" transistor line that operates the coolest. General Electric Company, Semiconductor Products Dept., Electronics Park, Syracuse, N. Y.

TYPE 2N333-THROUGH-2N335 SILICON TRANSISTORS MEET MIL-T-19500/37A SPEC.

Designing to the new MIL-T-19500/37A Spec? General Electric types 2N333, 2N334 and 2N335 can be supplied from warehouse stock to meet this specification.

SPECIFICATIONS

Absolute Maximum Ratings (25°C)

Voltages		
Collector to Base	V_{CB}	45 volts
Collector to Emitter	V_{CE}	45 volts
Emitter to Base	V_{EB}	4 volts
Current		
Collector	I_C	25 ma
Power		
Collector Dissipation RMS	P_c	500 mw @ 25°C (Free Air)
	P_c	83 mw @ 150°C (Free Air)
Temperature		
Storage	T_{STG}	−65 to 200°C
Operating Junction	T_J	−65 to 175°C

Electrical Characteristics (Typical at 25°C)

		2N332A	2N333A	2N334A	2N335A	2N336A	
D C Characteristics							
Forward Current Transfer Ratio (low current) (I_C=1 ma, V_{CE}=5 V)	h_{FE}	16	27	36	45	75	
Saturation Voltage (I_B=1 ma, I_C=5 ma)	V_{CE} (Sat)	.5	45	.42	.4	.4	volts
Cutoff Characteristics							
Collector Current (V_{CB}=30 V; I_E=O; T_A =25°C)	I_{CBO}	1	1	1	1	1	mμa
Collector Emitter Current (V_{CE}=30 V; I_B=O; T_A =150°C)	I_{CEO}	60	60	60	60	60	μa
Low Frequency Characteristics (V_{CB}=5 V; I_E= −1 ma; f=1000 cps)							
Forward Current Transfer Ratio	h_{fe}	16	30	38	52	95	
Input Impedance	h_{ie}	750	1300	1700	2000	3700	ohms
Output Admittance	h_{oe}	3.5	5.0	6.0	7.0	8.0	μmhos
Output Admittance	h_{ob}	.25	.2	.18	.15	.13	μmhos
High Frequency Characteristics (Common Base) (V_{CB}=5 V; I_E= −1 ma)							
Output Capacity (f=1 mc)	C_{ob}	7	7	7	7	7	μμf
Cutoff Frequency	f_{ab}	10	11	12	13	15	mc
Power Gain (common emitter) (V_{CE}=20 V; I_E= −2 ma; f=5 mc)	G_e	11	11	12	12	12	db

GENERAL ELECTRIC

CIRCLE 121 ON READER SERVICE CARD

A Low-Conductivity Magnetic Flowmeter

How simple design changes have produced a magnetic flowmetering system that will handle liquids or slurries with conductivities as low as 0.1 μmho per cm.

DOUGLAS R. LYNCH, Fischer & Porter Co.

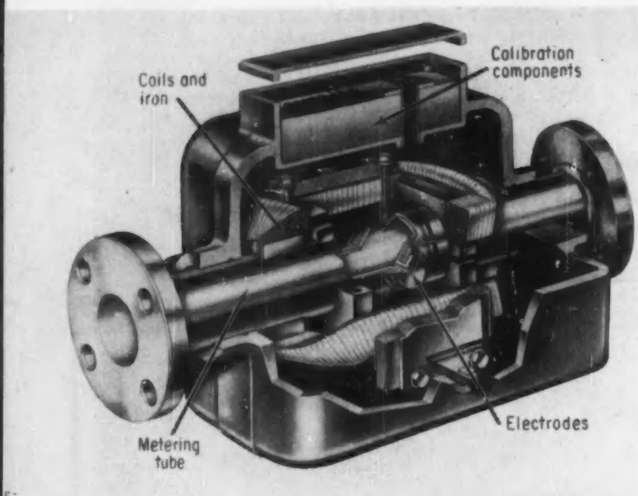


FIG. 1. Construction of a modern magnetic flow transducer.

Use of magnetic flowmeters in process control systems has been limited in the past to liquids of relatively high conductivity. To better understand techniques recently developed to extend this range of application, it would be well first to review the operation of a typical present day system.

The flow transducer

Essentially, a magnetic flowmeter system consists of a primary flow transducer and secondary amplification instruments. System performance depends on both these elements. Figure 1 shows a cutaway drawing of the transducer and illustrates its basic parts. This entire assembly behaves like an ac generator in which the conductive liquid serves as the driving armature. The equation relating flowrate to the induced voltage may be written as

$$q = KD(E_o/B)$$

where q is the volume flowrate, K a meter constant, D the diameter of the meter, E_o the induced voltage, and B the flux density of the magnetic field. The derivation of this equation is rather straightforward and need not be reviewed here. The equation shows, however, that for a given meter size, volume flowrate depends only on the relationship between the induced emf and the flux density and is completely independent of the many variables which normally affect the operation of conventional head meters.

In practice it is difficult to maintain a constant flux density B, but it is relatively simple to maintain the E_o/B ratio. Generally this is accomplished by using the output of a transformer (connected either in series or in parallel with the field coils) in conjunction with external dividing networks to produce a reference volt-

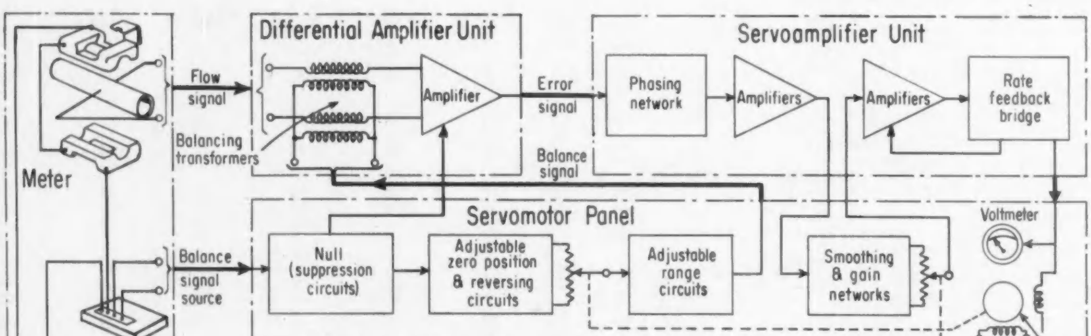


FIG. 2. Block diagram of a typical magnetic flowmetering system.

age. Then, any disturbance which affects the flux density will similarly affect the signal voltage.

Experiments have shown that the meter coefficient K is essentially constant provided that the magnetic field is uniformly distributed and the fluid conductivity remains above the minimum threshold. Hence the meter is fully independent of Reynolds number.

Secondary instruments

Figure 2 shows a complete system using a special servo-driven null-balance potentiometer. The emf generated at the meter goes directly to high impedance balancing transformers. The balancing signal from the current transformer in the meter is operated on by a balancing network in the servomotor panel before being applied in phase opposition to the flow signal in the differential amplifier. That portion of the available balancing signal to be applied as a comparison voltage against the flow signal is a function of the angular displacement of the closed-loop servosystem from a null or balance position. The balancing network also provides a suppression voltage for unwanted longitudinal pickup and quadrature voltages that appear on the high impedance transmission cable or in the primary meter electrode leads. This suppression voltage is introduced to the differential amplifier unit for pickup cancellation. The error signal then enters the high gain servoamplifier which boosts it to a level sufficient to drive the servomotor, provides a phasing adjustment to maintain proper phase relationship with the servomotor, applies rate-feedback to prevent overshoot, and also permits external gain adjustment. The amplified error signal then passes to the servomotor which mechanically positions both the recorder pen and the potentiometer in the balancing network. When the balancing signal equals the flow signal, the system will be in balance.

Lowering the conductivity threshold

A liquid conductivity of 20 μmhos per cm has been suggested as a practical minimum for magnetic flowmeters. This figure however includes a wide safety margin since tests under laboratory conditions have shown that conductivities as low as 1.57 μmhos produce little change in the flow coefficient.

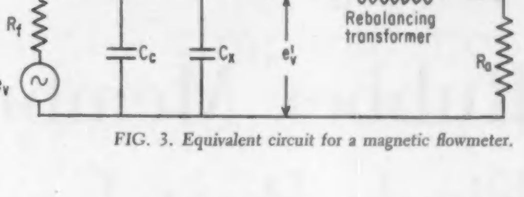


FIG. 3. Equivalent circuit for a magnetic flowmeter.

Figure 3, an equivalent circuit for a magnetic flowmeter, illustrates the approach taken in developing a system for even lower conductivities. Since the input impedance of the differential amplifier R_a poses no loading problem, and further, since the resistance of the fluid R_f is the quantity to be determined, these values need not be varied. The clue to lower conductivity thresholds, then, lies in reduction of cable capacitance C_c and transformer capacitance C_x.

The newly designed system is shown in Figure 4. As a first step, the balancing transformers were moved from the secondary instrumentation to the vicinity of the primary. Maximum allowable cable length was set at 20 ft. Next, residual cable capacitance was minimized by using twin shielded electrode cables and allowing the outer shields to serve as electrostatic shields while the inner ones are driven to the same potential as the center conductor by the rebalancing voltage. This technique neutralizes the capacitive loading between center conductors of the two leads. A circuit analysis showed that maintaining the inner shields at a slightly higher potential than the conductors would also neutralize the remaining transformer capacitance.

In today's "high-conductivity" systems the problem of quadrature voltage is eliminated by use of phase-sensitive components. However, with higher fluid resistances the phase of the quadrature shifts so that some in-phase component is added to the signal. The next step was to add a second servosystem, phase-sensitive to quadrature voltage alone. The rebalancing voltage then serves a second purpose in that it also drives the inner shields to the same quadrature potential as the center conductors, thus maintaining quadrature voltage in its proper phase relationship.

Finally, a considerable reduction in noise interference and zero stability problems has been brought about by 1) development of a transistorized differential amplifier and power supply, 2) careful attention to special noise producing circuit details, and 3) lifting all intermediate grounds in favor of a single-point grounding system.

While the changes described above have produced a magnetic flowmeter system capable of handling liquids with specific conductivities as low as 0.1 μmho per cm (or about one-tenth the conductivity of distilled water), they have by no means exhausted the possibilities of further improvement in the near future. The present limit, like its 20 μmho predecessor, provides a wide safety margin; it too is subject to considerable reduction under laboratory conditions.

← OLD SYSTEM VS NEW ↓

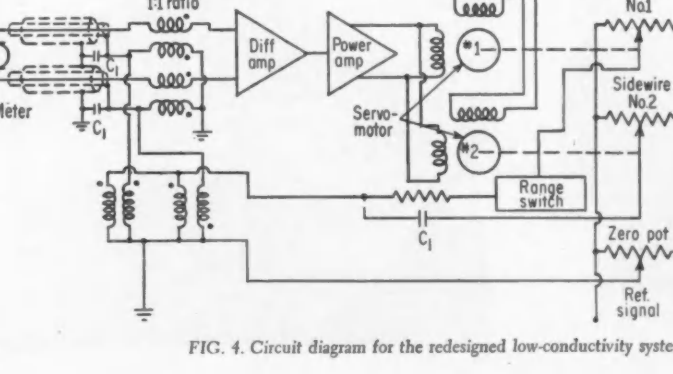


FIG. 4. Circuit diagram for the redesigned low-conductivity system.

IDEAS AT WORK

Rubber Membrane Finds Root Loci

T. JAWOR, Evershed & Vignoles Ltd., London

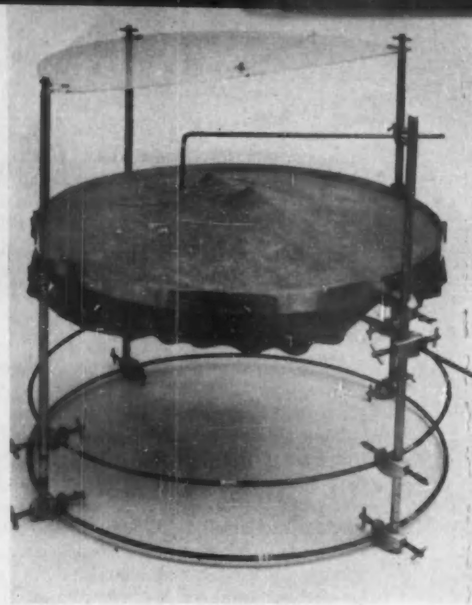


FIG. 1. A 0.01-in. thick stretched rubber membrane is displaced by rods at the poles and zeros to generate the root locus.

A function $Z(s) = \ln G(s)$ of a complex variable $s = \sigma + j\omega$ can be approximately represented by local distortions of a uniformly stretched elastic membrane from a reference plane according to the locations of the poles and zeros of $G(s)$. In control problems, $G(s) = G_A(s)\ G_B(s)$ is a loop transfer function consisting of a rational part $G_A(s)$ and a transcendental part $G_B(s)$. Being rational, $G_A(s)$ can be factored to yield explicitly the location of its poles and zeros (see "Using the Root Locus", CtE, October '59, pp. 96-102).

Thus, by displacing an elastic membrane upwards at the poles and downwards at the zeros of $G_A(s)$, its surface represents $\ln G_A(s) = \ln |G_A(s)| + j \arg G_A(s)$. The contour lines of the surface (constant height from reference plane) are the lines of constant magnitude or gain, while the streamlines orthogonal to the contours are lines of constant phase. Poles and zeros of $G_A(s)$ arise from the transfer functions of the loop elements. Their location in the s-plane is determined by the time constants of these elements. $G_B(s)$ is a transcendental function characterizing a distance velocity lag (DVL) or a distributed lag (DL). It is difficult to represent the latter, since a quartic surface is required for $\ln e^{-Ts}$. DVL on the other hand can be represented simply by tilting the entire reference plane by an angle $\phi = \tan^{-1}(-T)$ to the horizontal, T being the DVL time constant. DVL phase lines are equidistant and parallel to the real axis.

Since DVL has a greater instability effect than DL, only DVL is considered hereafter.

The locus of the two complex control roots determining the stability of the associated control system is the path of the steepest descent from a saddle point on the membrane between two real poles nearest the origin (or from two complex poles if they are nearest).

A light chain with its center near the saddle point will take up the position along the path of the steepest descent and hence along the root locus when the surface is lightly tapped. Variations of the locus with that of the pole-zero configuration representing the system can be seen directly.

Figure 1 shows a rubber model making use of this theory. Small diameter rods displace a 0.010-in. thick, 2-ft diam. rubber membrane stretched over a steel ring and clamped by an aluminum band.

All rods at first order poles and zeros are shifted by the same amount (2 in.) from the plane of the membrane. At higher order poles and zeros, the shift is proportionately greater. The rods are steel with rounded $\frac{3}{8}$-in. diam. aluminum tips. They are set and clamped to the supporting framework by adjustable clamps.

The steel ring carrying the membrane can be rotated about an axis in the plane of the membrane, and then

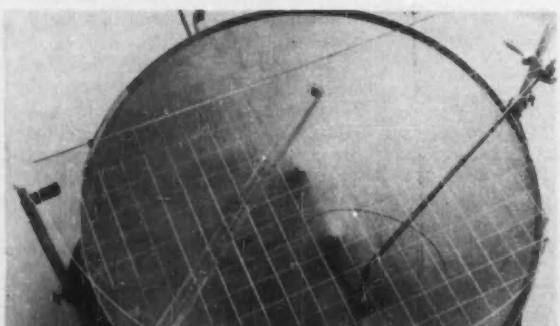
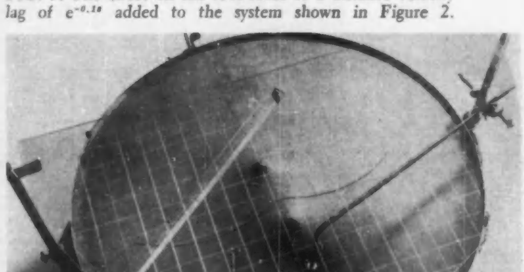
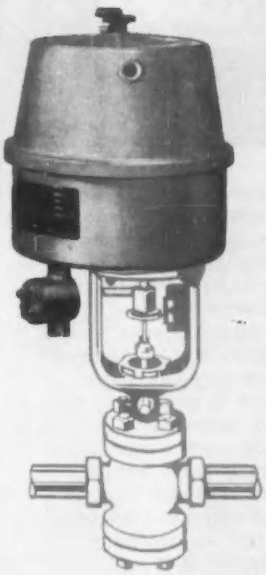


FIG. 2. The root locus of a first order plant and two-term controller where $G(s) = (s + 5)\ s\ (s + 3)$.

FIG. 3. The effect on the root locus of a distance velocity lag of $e^{-0.1s}$ added to the system shown in Figure 2.



Electro-Hydraulic Valve Actuators by **GPE Controls** offer the simplest, most compact, lowest-cost way to operate control valves from an electric signal. Model 698 shown positions 1¼″ double-seated valve at 1000 p.s.i. pressure drop, with input signal ranges of 1-5, 4-20, or 10-50 ma. Completely self-contained. Easy, low-cost installation. Position repeatability within .002″. Automatic locking with power failure simplifies start-up of process. Division I construction for hazardous service is standard. Other models available for heavier duty.



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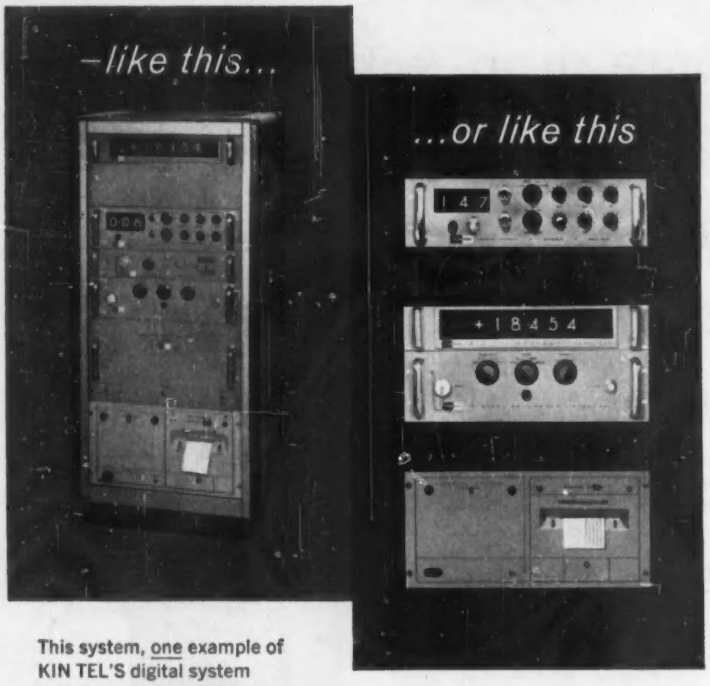
A Subsidiary of GENERAL PRECISION EQUIPMENT CORPORATION

CIRCLE 125 ON READER SERVICE CARD

For high-accuracy data logging...to checkout missiles or meters, to test transducers or transistors...checkout a KinTel digital system



This system, one example of KIN TEL'S digital system experience, takes eight measurements at each of 7200 different data points. Outputs include visual readout, digital printer, X-Y recorder, and tape punch. Tape is perforated for direct entry into a digital computer. To provide 0.01% accuracy for low-level inputs, alternate channels scan calibration signals. These, with the unknown input signal, are fed to the computer and correction is made for any inaccuracy in the system itself. Cost: about $20,000.

This data system consists of a KIN TEL 453M scanner and 501 DC digital voltmeter, plus a parallel entry printer. Briefly, the system will accept 400 one-wire, 200 two-wire, or 100 four-wire inputs, and will provide both visual and printed indication of the channel being scanned and DC input signals from ±100 microvolts to ± 1000 volts. Accuracy is 0.01% ±1 digit, and ranging and polarity indication are automatic. The complete system costs approximately $6850. At the present time, delivery is off the shelf.

KIN TEL DIGITAL SYSTEM CAPABILITIES

You can have any number of channels: A single 453M scanner ($2500) accepts 400 one-wire, 200 two-wire, or 100 four-wire inputs. Additional scanners can be added if more inputs are required.

You can measure DC from ±1 μv to ±1000 volts: The KIN TEL 501 DC digital voltmeter ($2995) measures from ±100 μv to ±1000 volts. Addition of a KIN TEL digital preamplifier increases sensitivity to 1 μv DC.

You can measure AC from 10 μv to 1000 volts: Addition of a 452 AC converter ($850) to the 501 DC digital voltmeter permits measurement of RMS AC voltages from 1 mv to 1000 volts in the frequency range of 30 cps to 10 kc. A KIN TEL preamplifier can be added to increase AC measurement sensitivity to 10 μv from 30 cps to 2 kc.

You can measure voltage ratios: The 507B digital voltmeter/ratiometer ($3835) measures DC voltages from ±100 μv to ±1000 volts and DC/DC ratios from .0001.1 to 999.9·1. Accuracy is 0.01% ±1 digit. Addition of appropriate converters permits AC/DC and AC/AC ratio measurements.

You can get 0.01% DC and 0.2% AC accuracy: The KIN TEL 502 AC/DC digital voltmeter ($3845) measures DC from ±100 μv to ±1000 volts with 0.01% ±1 digit of reading accuracy, and AC from 1 mv to 1000 volts, 30 cps to 10 kc, with 0.2% of full scale accuracy.

You can have 10,000 megohm input impedance: The KIN TEL 458A digital voltmeter preamplifier ($1225) has gain positions of 100 (for DC and 30 cps to 2 kc AC measurement) and +1 HI Z (for DC only). On the +1 gain position input impedance is >10,000 megohms and gain accuracy is 0.001%. Input range for +1 operation is 0 to 40 volts.

You can have visual, printed, or any other form of output: KIN TEL digital voltmeters provide visual indication of the measured quantity on a single-plane in-line readout. They are capable of directly driving commercially available 10-line parallel input digital printers. Converters are available for driving other types of printers, paper tape punches, typewriters, and IBM card punches.

To find out how a KIN TEL digital system can solve your particular data acquisition problem, send us an outline of your requirements, or contact your nearest KIN TEL engineering representative.

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clamped at any desired angle to the horizontal plane. A pointer (not visible in the figure) is attached to the rim of the ring in the plane of the membrane, and the inclination ϕ is read off against a scale calibrated in tan ϕ on the supporting frame. A transparent Plexiglas graticule mounted above the ring supplies a reference grid for location of poles and zeros. Since only poles and zeros with negative real parts are of interest, the graticule extends over the negative half plane only. The $j\omega$ axis lies directly over the axis of rotation of the membrane and the origin lies above the center of the membrane. A Plexiglas arm pivoted at the origin slides over the graticule. A straight line (the "relative damping line") engraved on it can be set against an angular scale engraved on the edge of the graticule. Unit length on arm and axes is 1 in.

In spite of the finite size and displacement of the membrane and surface distortion due to the weight of the chain, the approximate representation of the function Z(s) is good enough to demonstrate the effects of parameter shifts on system stability.

Set-up procedure

To set up a rubber membrane solution, proceed as follows:

1. Split the open-loop transfer function into its rational and transcendental parts.
2. Factor the rational part to obtain the poles and zeros.
3. Choose a convenient time constant and express all other time constants in terms of the chosen one.
4. Tilt the ring carrying the membrane (thus raising the negative real half plane) until the pointer registers the total DVL nondimensional time constant and clamp the ring in this position.
5. Locate positions of poles and zeros using the graticule, and bring all displacement members to the plane of the membrane (from underneath at poles and from above at zeros).
6. Shift the displacement members vertically 2 in. upwards at simple poles and 2 in. downwards at simple zeros. Increase the shift proportionately for higher order poles and zeros.

The loop transfer function is then represented by the membrane. To obtain the root locus locate the saddle point nearest the origin and place a light chain on the membrane with its mid-point close to the saddle point. Tap the membrane lightly to make the chain take up the position along the root locus.

To determine whether the stability and transient response of the system are satisfactory, express these specifications as a condition on the location of control loops in terms of the relative damping ζ and the natural frequency s_n of the system (expressed in terms of the selected time constant). Position the arm against the required value on the scale of ζ, and observe whether the chain lies vertically below the point on the arm specified by s_n. If it does, the specifications are met assuming the required loop gain is available.

If the chain does not lie below the point on the arm, manipulate the rods representing the parameters under designer's control to bring it there. The values of these parameters can then be read off using the graticule.

A locus for a system consisting of a zero and two poles, such as a first order plane and a proportional plus integral controller, is shown in Figure 2. Here $G(s) = (s + 5)/s(s + 3)$. Figure 3 shows the effect on the locus of an additional DVL of the value $e^{-0.1s}$.

For a particular configuration of poles and zeros an (imaginary) section along the $j\omega$ axis of the membrane represents the log gain/frequency response of the system. The frequency scale in this case is linear.

Transfluxor Analog Memory

MURRAY KRAUS, Applied Science Corp. of Princeton

The transfluxor ferrite memory core developed by RCA Laboratories (Reference) has been adapted by the Applied Science Corporation of Princeton (ASCOP) for use as an analog memory in their industrial pulse-width telemetering system. In this system a dc voltage V_i, representing a measured value, is sampled for $\frac{1}{10}$ sec every few seconds (see diagram). The memory provides a continuous output signal V_o identical to the last received sample.

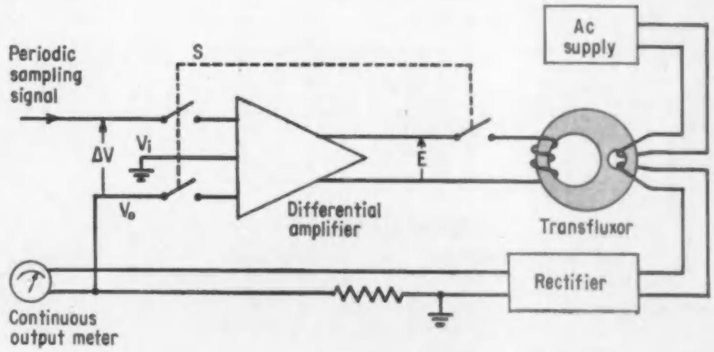
The transfluxor is essentially a variable transformer. The ratio of the primary current from the ac supply to the secondary voltage into the rectifier can be altered by changing the coupling between the two windings. This coupling is a function of the magnitude and polarity of the last impressed dc voltage E (which can be removed) on the transfluxor's third winding. The transfluxor's nonlinearity and temperature instability are made negligible by negative feedback.

In the telemetering system, switch S closes when the sample voltage is received. If signal V_i differs from the existing memory output V_o, an input voltage ΔV is present. The output voltage E from the amplifier increases rampwise from zero with a polarity dictated by the sign of ΔV. This voltage progressively changes the coupling to make V_o approach V_i. When the two are identical (well within the $\frac{1}{10}$ sec sampling time allotted) the ramp action ceases and switch S reopens.

In the actual system, one amplifier sets several memories by sequential switching of samples.

REFERENCE

THE TRANSFLUXOR, Rajchman and Lo, "Proceedings of the IRE", March 1956.



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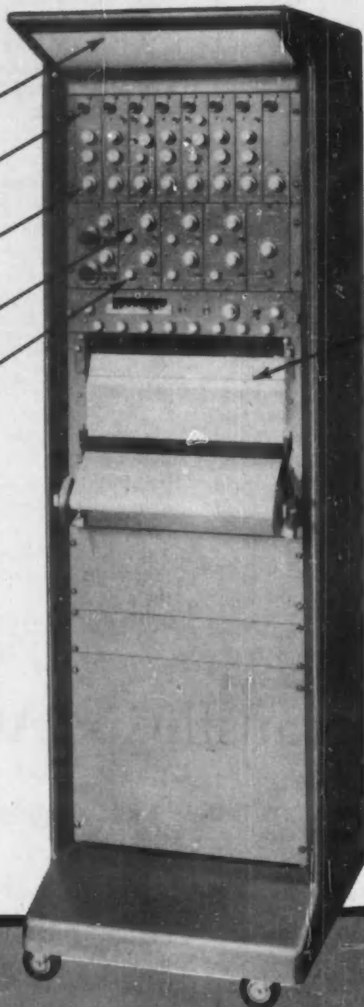

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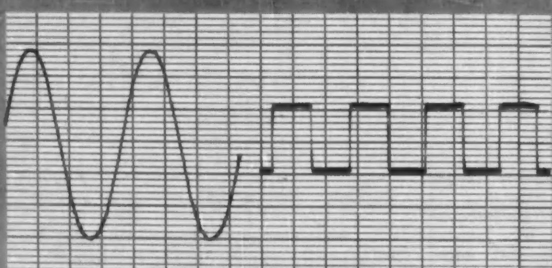

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CIRCLE 128 ON READER SERVICE CARD

Pneumatic Controls Refuel Jet Aircraft

ROBERT L. BECKTEL
RALPH H. LEBOW
Parker Aircraft Co.

Conventional piston engine airplanes are refueled from fuel trucks via wing-top openings, a satisfactory practice for aircraft that need a maximum of 6,000 gallons of fuel. New jet airplanes, however, can carry three to five times more fuel. Tank trucks for jet refueling would have to carry 22,000 gallons and their initial cost and roadability would make them impractical. Also refueling would be too slow and costly because the jets would be on the ground too long. As a result, the problem of refueling huge jets can only be solved with high speed pressurized techniques in which fuel is loaded aboard the airplanes at flow rates up to 1,200 gpm.

The jet refueling system must also be extremely versatile. The range of commercial turbine transports which will soon service the public includes Britain's Britannia, Comet IV, Viscount, and Vanguard; America's Boeing 707, Douglas DC-8, Convair 880, Lockheed Electra, and Fairchild F-27; and France's Caravelle. Each of these, and even different carriers using the same aircraft, may prefer pumping fuel aboard at different pressures. Thus, pressure control over a wide range of fueling rates is one of the prime requisites in the refueling system. Flow rates of 15 to 600 gpm and pressure control of 30 to 50 psi have been designed into the new, all-pneumatic ground refueling system developed by Parker Aircraft Co. for static, hydrant-type operations and also being built for mobile tank-truck installations.

Figure 1 shows the elements of the refueling system in a typical hydrant-type operation. Fuel is transferred from underground storage tanks through the pressure control valve to the hydrant vehicle where the metering equipment, filters, and hose reels are located. Connections are made to underwing fueling adapters with specially designed underwing nozzles. A distribution manifold in the aircraft feeds the fuel to the several tanks where level control valves insure that the tanks do not overfill. In addition, a low overshoot in the event of emergency shut-off had to be provided. The nature of a fueling system precludes electrical control elements.

Control of system pressure and flow is provided by the pressure control valve shown in Figure 2. This valve employs a dual retractable swing "flapper" for uniform control over a wide flow range, the center plug opening first for small flows and the entire flapper for larger flows.

Pressure control

The pressure control valve setting is maintained by two servovalves which respond to pressures provided by 1) the regulated air pressure source which sets the desired fuel pressure by establishing a reference pressure level and 2) the fuel sensing line which monitors the fuel pressure at a venturi mounted on the hydrant vehicle.

As air pressure from the regulated supply on the hydrant vehicle is initially applied to the system, the fast closing servopoppet closes and the regulator servopoppet opens. Pressure from the main diaphragm chamber bleeds downstream through the regulator servopoppet allowing the dual retractable flapper valve to open slowly. Rate of opening of the main valve is controlled by regulating the bleed rate by a needle valve in the line connecting the main diaphragm chamber with regulator servopoppet.

When the fuel pressure sensed at the venturi matches the preset regulating air pressure, the regulator servopoppet moves in a closed direction and restricts the flow from the main diaphragm chamber. This causes the main diaphragm chamber pressure to more nearly approach upstream pressure and throttles the valve to maintain preset regulated pressure at the venturi, the sensing and control location.

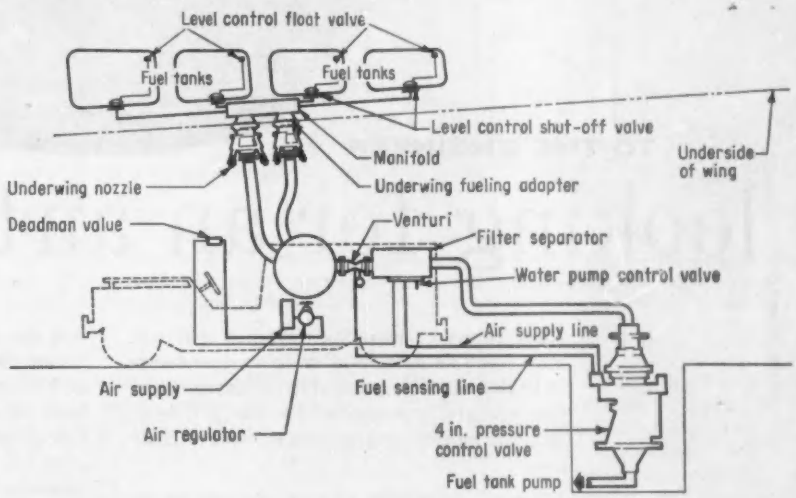

FIG. 1.
Refueling system measures pressure at hydrant vehicle venturi to control hydrant valve.

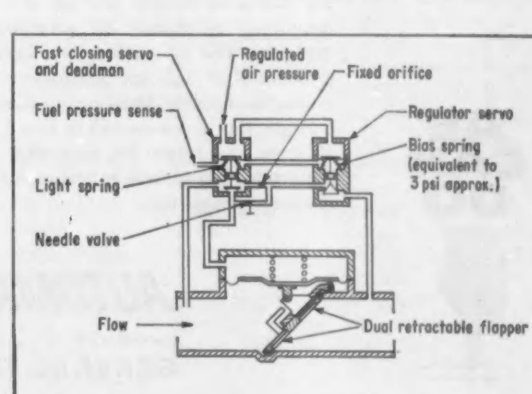

FIG. 2.
Fast opening pneumatic servo at left prevents fuel spillage in emergencies; regulating servo at right controls preset pressure at measuring venturi.

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AUTOMATIC ELECTRIC GENERAL SYSTEM

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Subsequent variations in the sensed fuel pressure reflecting changes in flow conditions (such as airplane tanks shutting off) generate movements in the regulator servopoppet. The regulator servo acts to alter bleed from the main diaphragm chamber such that positioning of the main flappers restores the sensed pressure to that preset.

Due to a bias spring in the regulator servo, the fast closing servo requires approximately 3 psi higher fuel sense pressure to operate. Thus, for a rise in downstream pressure too fast for the regulator servo (indicative of a major restriction in the fuel system), the fast closing servopoppet opens when the pressure reaches approximately 3 psi above the preset pressure. As the fast closing servopoppet opens, upstream pressure enters the main diaphragm chamber, rapidly moving the main valves in a closing direction to prevent over-pressurization of the system downstream of the regulator. A similar sequence occurs should the regulated air pressure be cut off by the "deadman" valve. Tests show that closing time is less than 1 sec with only 10 gal of fuel in overshoot.

The fuel line pressure is sensed at the hydrant vehicle. If the pressure at this point were fed back to the pressure control valve, the system would neglect the pressure loss between the vehicle and the aircraft. To correct this condition, the venturi is tapped at the inlet and the throat and the taps joined at a tee fitting. Each tap is fitted with a needle valve. By adjusting the needle valve the pressure at the tee can be set to equal the pressure desired at the aircraft. Once the needle valves have been set, they need no adjustment because the pressure drop through the venturi exactly matches the line loss as a function of flow rate.

A Hall Effect DC Resolver

LOUIS E. FAY, III
Research Laboratories Div.,
Bendix Aviation Corp.

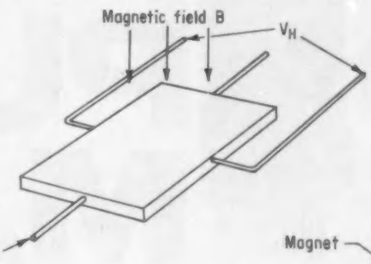

FIG. 1. The Hall effect produces a voltage V_H on a crystal as a function of field B and current I_s.

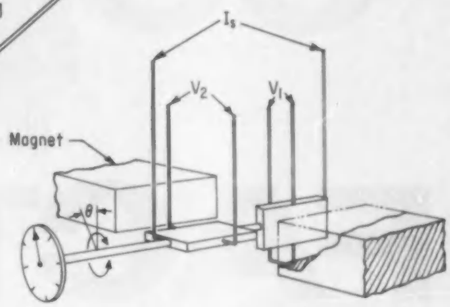

FIG. 2. A dc resolver using the Hall effect to generate orthogonal voltages V_1 and V_2.

An ac resolver is easily made using inductive coupling to obtain the sine and cosine terms. A dc resolver is more difficult to make. Special taper potentiometers which are expensive, cumbersome, and somewhat short-lived are used to get the sine and cosine terms. The Hall effect has been used to make a cheaper, more reliable dc resolver.

The Hall effect is a galvanomagnetic effect which is the solid-state analog to the magnetic deflection of the electron beam in a television tube. An electric current I_s is passed through a crystal in a direction perpendicular to a magnetic field B. The crystal is usually a thin rectangular plate oriented as in Figure 1. The current carriers, either electrons or holes, are deflected in a direction mutually perpendicular to both I_s and B. Some of the deflected carriers pile up at the edges of the crystal and generate an electric field which opposes the magnetic deflection. When the electric field equals the magnetic force, an equilibrium voltage is established across the edges of the crystal, which voltage is described as

$$V_H = \frac{10^{-8} R_H I_s B}{t}$$

where I_s is in amperes, B in gausses, t is the thickness of the crystal in cm, and R_H is the Hall coefficient measured in cu cm per coulomb. R_H depends upon bulk properties of the crystal such as resistivity and carrier mobility. Correction factors for crystal geometry and electrode size can be absorbed into R_H. Commonly used materials with high R_H values are silicon, germanium, indium antimonide, and indium arsenide.

To make a dc resolver, two identical Hall crystals were mounted on a shaft in a uniform magnetic field so that the current axes of the crystals were parallel to the axis of rotation of the shaft and the voltage axes of the crystals were mutually perpendicular and also perpendicular to the shaft axis, as in Figure 2. By passing a *constant* current I_s through the two crystals in series, the Hall voltage from each crystal becomes primarily a function of the effective magnetic field, B_{eff}, which varies sinusoidally as the crystal rotates and intercepts more or less of the field in the plane of the electrodes. Thus in Figure 2,

$V_1 = kB_{max} \cos\theta$ and $V_2 = kB_{max} \sin\theta$

which are the two voltage components desired of a resolver. The term k is a constant over a limited range depending on the geometry and material of the crystal and the temperature.

The major objection to this resolver is that V_1 and V_2 vary sinusoidally about two different dc levels that depend on I_s. In other words, the mutually perpendicular current and voltage circuits are not isolated for dc. One solution is to supply I_s for the crystals from a floating dc supply; batteries are practical in a transistorized system for example.

Resolvers using indium antimonide crystals have produced peak-to-peak output voltages of 200 mv in a field of 2,700 gausses. Standard resistance compensating circuits were used to make the output zero for $B_{eff} = 0$ and to calibrate the maximum output to the scale desired.

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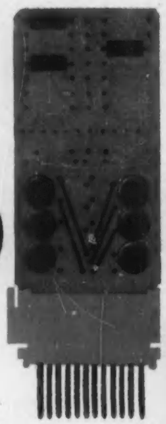

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Simplified schematic at the right illustrates the operation of a typical 10-finger model. Unit contains a rigid assembly consisting of the armature, actuator, and tapered lift bar. This entire assembly is attached to a flexural pivot so that when the actuator moves down, the lift bar rises. In the position shown, all but one of the resilient fingers are depressed, leaving nine of the ten resistors in series with the controlled circuit. As the lift bar rises in response to an increased input, additional contact pairs close and sequentially short out more of the total resistance. Travel for full output range measures ⅛ in. at the point of connection to the actuator. Actually, the control resistors are housed in a separate box and can be furnished for either series or parallel connection to the controlled circuit. Various resistance values may be specified to provide any desired transfer curve.

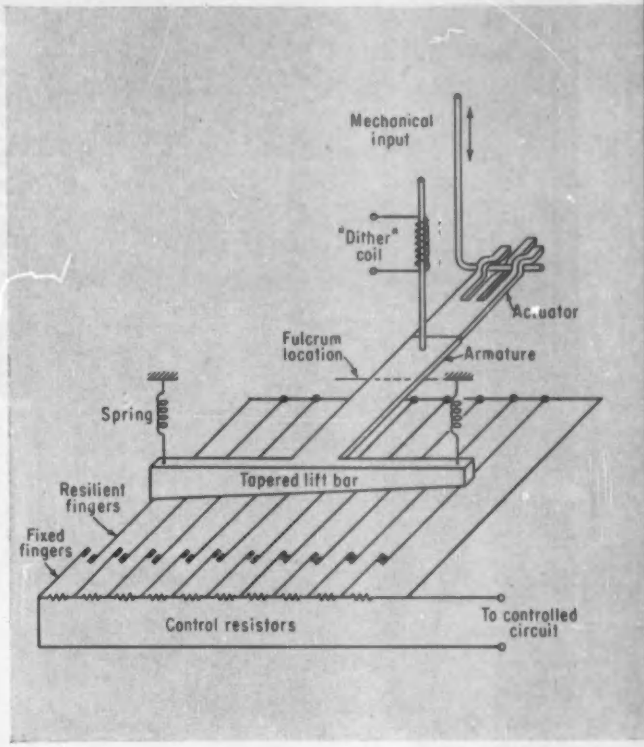
Also shown in the schematic is a dither coil magnetically coupled to the armature. This serves two functions: 1) it supplies a 60-cycle dither that smooths out the transfer curve by providing average values of resistance between the discrete steps, and 2) it balances the reference springs so that only a 10-gram input force is required at the actuator. This same coil can also be designed to handle a variable electrical signal. In this case the controlled circuit would respond to the sum of both the electrical and mechanical inputs.

Chief advantage of these units is their power handling capability. A single 20-finger model with its associated resistor chassis will dissipate up to 200 watts and directly control circuits in the low kilowatt range. Rugged, dust-tight, tamper-proof construction and the complete absence of brushes and bearings assure a life expectancy of up to 100,000 hr in moderate power applications.

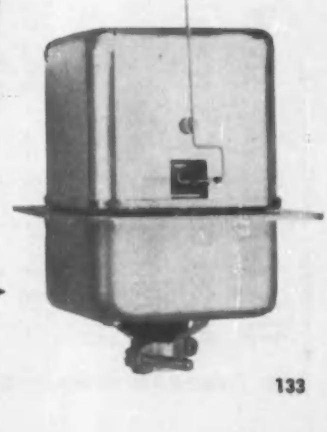
Uses include the measurement and control of tension, position, temperature, pressure, force, etc. Units may be directly connected to bellows, springs, levers, Bourdon tubes, bimetals, or cams. Photos at the right show two of the many possible configurations. One unit is equipped with a knob for manual operation. Used with an adjustable-resistance chassis, it serves as a highly flexible laboratory tool. The second unit, designed to sense linear motion, features a mating, plug-in, fixed-resistor chassis.

In one current application two such devices have simplified the control of a thread winding machine—one in a closed-loop system for measuring and controlling tension, the other in an open-loop system that controls motor speed in response to the increasing diameter of a take-up roll.—Electric Regulator Corp., Norwalk, Conn.

Circle No. 280 on reply card



Rotary type designed for manual operation



Linear motion type with fixed resistor chassis

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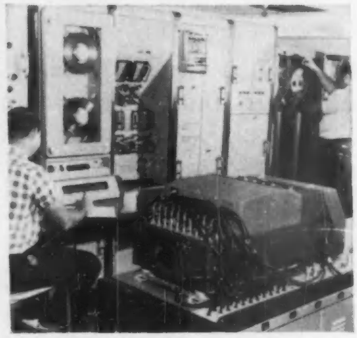

FLIGHT DATA SYSTEM

Developed jointly by Douglas Aircraft and CEC's Datalab Div., a new high speed data handling system acquires and evaluates flight data in one-sixth the time previously required. This system consists of three stations: an airborne acquisition station, a mobile ground control and recording station, and a computer input station located at the Douglas plant and shown in the photo above. Outstanding features of the system are its high sampling rate of up to 55,000 measurements per sec and its ability to pack at least 1,000 data measurements per linear in. of tape.—Consolidated Electrodynamics Corp., Pasadena, Calif.

CIRCLE 281 ON REPLY CARD

MODULAR DESIGN

Photo above illustrates the clean design of a brand new digital computer, the Model 1604. A fully transistorized, large scale, general purpose machine, the 1604 features modular construction with an unusual degree of circuit standardization. A total of 7,000 printed circuit cards are used in a

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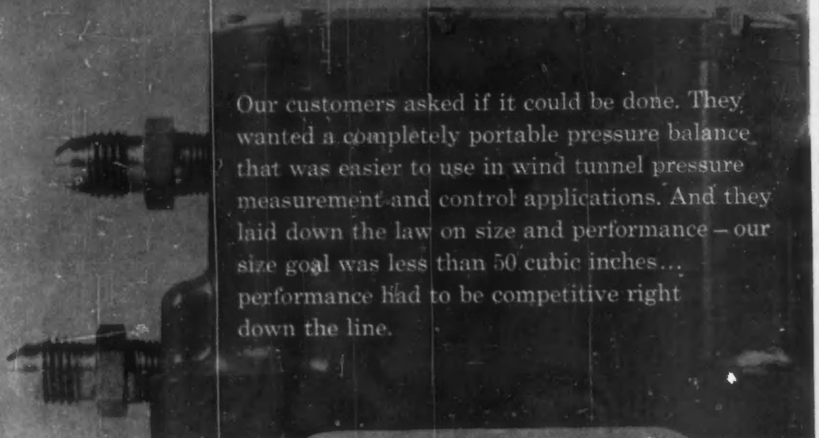

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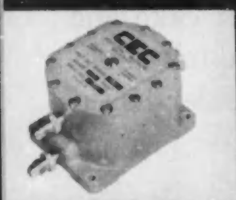


for complete information—on Model 4-332, the precision pressure balance you can hold in your hand, call your nearest CEC sales and service office or write for Bulletin CEC 1547-X1.

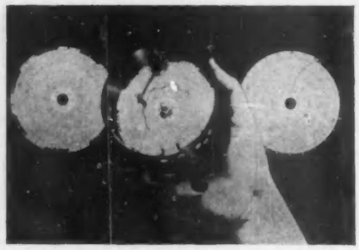
CEC

Transducer Division

CONSOLIDATED ELECTRODYNAMICS / pasadena, california

single 1604. Main cabinet (at the right) houses all arithmetic and control sections as well as a 32,768-word magnetic core memory. This cabinet measures 7½ ft long and 5½ ft high, weighs 2,200 lb, and consumes 4 kw. The Model 1607 tape system (upper left) is of similar dimensions and power consumption, and is designed for use with the 1604. A Model 1605 adapter can be provided to permit communication between the computer and a variety of IBM peripheral equipment. Applications of the 1604 range from large volume commercial data processing and scientific problems to defense systems control. Intended industrial applications include real time instrumentation for process control and automatic test data reduction.—Control Data Corp., Minneapolis, Minn.

CIRCLE 282 ON REPLY CARD



DRY STYLUS RECORDER

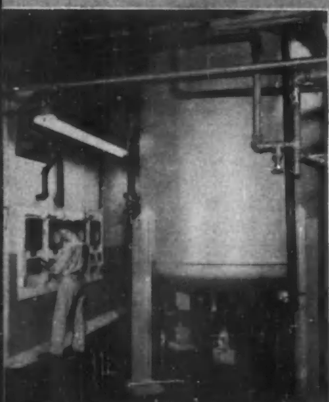
Powered by a spring-wound clock movement, this low cost recording thermometer provides an excellent means of recording time-temperature data in both mobile and stationary applications. Small enough to be packed with goods in transit, the device will record in any position. The thermometer uses a dry stylus—no ink to spill, freeze, or run. Two temperature ranges are available: 20 to 220 deg F or minus 40 to 160 deg F. Chart time is either 24 hours or 7 days. Unit sells for $37.50.—The Pacific Transducer Corp., Los Angeles, Calif.

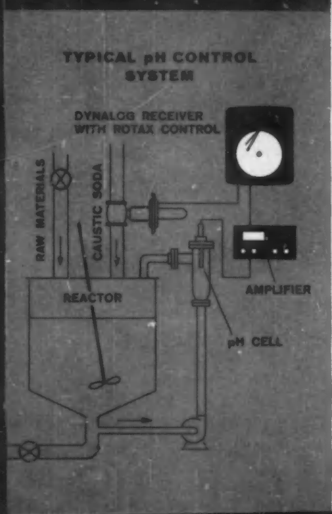
CIRCLE 283 ON REPLY CARD

PRECISION PLOTTER

The HR-94, a 24 x 36 in. X-Y recorder, is designed to operate from differential transformers and may be used to plot small mechanical movements or any related variables which can be converted to mechanical movements. The new plotter features an

← CIRCLE 136 ON READER SERVICE CARD





at Sika Chemical—

REACTORS CONTROLLED WITHIN 0.1 pH

by Foxboro DYNALOG* Recorder-Controllers

At Sika Chemical Corp., Passaic, N. J., control of pH in reactors is of vital concern in manufacturing "Plastimet," Sika's widely-used concrete densifying additive.

Sika finds Foxboro Dynalog Recorder-Controllers perfect for the job. Dynalog's smooth variable air capacitor (which replaces troublesome step-by-step slide-wires) responds instantly to the smallest change in pH value. A Rotax on-off control unit then initiates addition of enough caustic soda to return reactor pH to set point.

Sika reports maintenance on their Dynalogs has been almost nil. One tube replaced in three years. No lubrication ...no cleaning...no dry cells to standardize or replace. "In fact," says process engineer Gordon Morrison, "we're so confident of Dynalog's performance that our reactors run right through the night—unattended."

Dynalog Electronic Recorders—Controllers—Indicators deliver accurate, sensitive, measurement not only of pH, but of dozens of other variables as well. Get full details by writing for Bulletin 20-10. **The Foxboro Company, 8512 Neponset Ave., Foxboro, Mass.**

Reg. U.S. Pat. Off.

FOXBORO
REG. U.S. PAT. OFF.

DYNALOG ELECTRONIC INSTRUMENTS

CIRCLE 137 ON READER SERVICE CARD

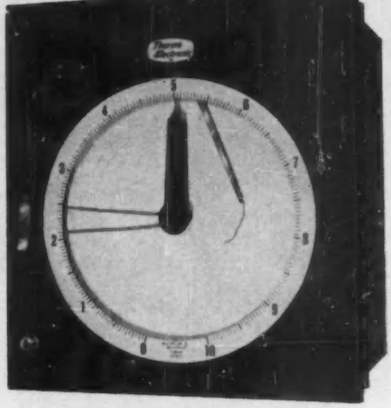
Versatility

makes the

difference

in the

Thermo® Electronic Indicating Recorder



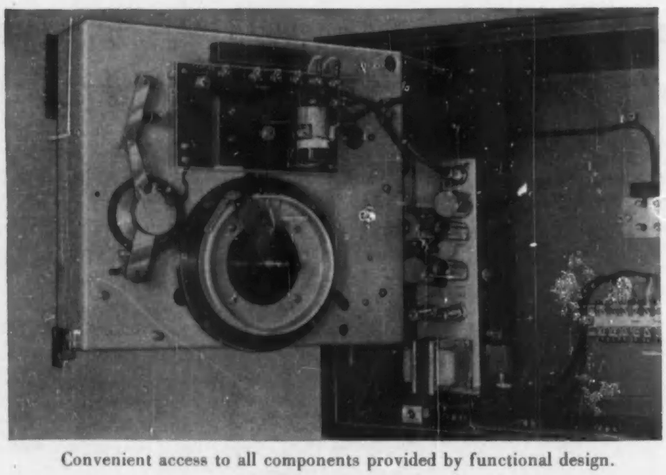
No matter what your application, you can rely on Thermo Electronic Recorders for unsurpassed accuracy, sensitivity and stability. Both potentiometer and bridge types are available. These instruments will automatically indicate and record any process variable (temperature, humidity, pH, conductivity, power, strain, etc.) that can be converted to a voltage or resistance change. Instrument accuracy is ± 0.25% of full scale, sensitivity is ± 0.125% and full scale pointer and pen travel is 5 seconds. The 34" scale and indicating pointer are clearly visible from a great distance.

In use, you get a continuous fine-line circular chart record of your process. Recording pen rarely needs refilling. Easily interchanged ranges permit recording of an almost unlimited variety of process variables.

The heart of the Indicating Recorder is the exclusive Thermo Electronic high-gain servo-amplifier, which couples exceptional stability (±1 microvolt) with extreme sensitivity. It will maintain operating characteristics even under the most adverse conditions. This guarantees consistently accurate performance in recording your process functions. Full sensitivity of the amplifier is used in standardization. Two or three position controls, or up to six alarm contacts are optional. Built-in fail-safe action is standard.

Your recording requirements can best be met with Thermo Electronic Instruments.

Write today for Catalog 66-B



Convenient access to all components provided by functional design.

Thermo Electric CO., INC. SADDLE BROOK, NEW JERSEY

In Canada: THERMO ELECTRIC (Canada) LTD., Brampton, Ontario

adjustable multiplication factor that permits as much as a 1,000 to 1 amplification of mechanical motion with a total error of less than 0.15 percent. Normally the instrument uses 24 x 36-in. drawing sheets or 24-in. roll stock graph paper, but a dual vacuum hold down system also permits the use of half size sheets. A built-in tuning fork oscillator provides 400-cps power for the signal, reference, and rebalance circuits. The servosystems operate on standard 50- to 60-cps line frequency. Pen speed with standard servo is 2 in. per sec. Higher pen speeds and electronic subassemblies to accommodate low level dc inputs are available as optional features.—Houston Instrument Corp., Houston, Tex.

Circle No. 284 on reply card

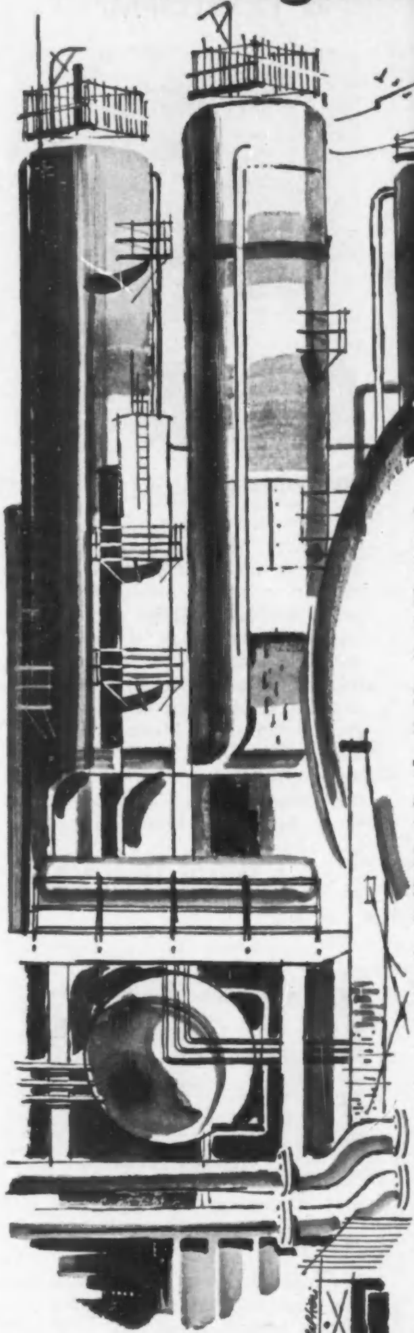
SMALL BUT POWERFUL

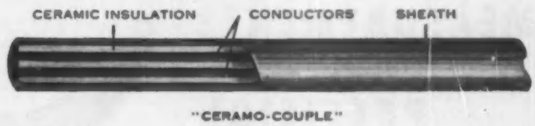
Split second answers to scientific and engineering problems are provided by this IBM 1620 data processing system. Part of the system is a small transistorized computer which can perform more than 100,000 calculations per min. Requiring little more space than the average desk, the system operates under the direction of an internally stored program and is particularly suited for applications like highway cut-and-fill and bridge design, oil pipe-line transmission and product inventory, petroleum blend evaluation, power requirements analysis, etc. Features include 2,000 digits of magnetic core storage with variable field length and immediate accessibility, paper tape input, and electric typewriter output. Two advanced programming systems and a library of routines simplify programming. System will rent for $1,600 per mo and sell for $74,500.—International Business Machines Corp., White Plains, N. Y.

Circle No. 285 on reply card

1,000 Ceramo® Thermocouples

Safeguard New Multi-Million Dollar Petrochemical Complex





At the Lake Charles, La. plant of Petroleum Chemicals, Inc., controlling temperatures from 300° below zero to over 2000° F. is critical. Thermocouples installed throughout the plant must withstand corrosive atmospheres, high pressures, and high velocity gas streams. Despite this "rough treatment", these thermocouples must be long-lived to cut costly down-time. They must be accurate and sensitive to eliminate the possibility of malfunction.

Small temperature deviations might upset a complete process—without reliable sensing elements, untold damage could result.

To assure protection of their installation—including the world's largest ammonia plant reactor, Petroleum Chemicals, Inc., chose Thermo Electric "CERAMO-COUPLES". They particularly like "CERAMO" because they have been able to depend on the inherent superiority of the ceramic insulated, metal sheathed thermocouple wire, for long in-service life, and continuous accuracy.

"CERAMO", introduced by Thermo Electric in 1951, is now recognized as an industrial standard for temperature sensing elements . . . many thousands of "CERAMO" thermocouples are being used in installations throughout the world.

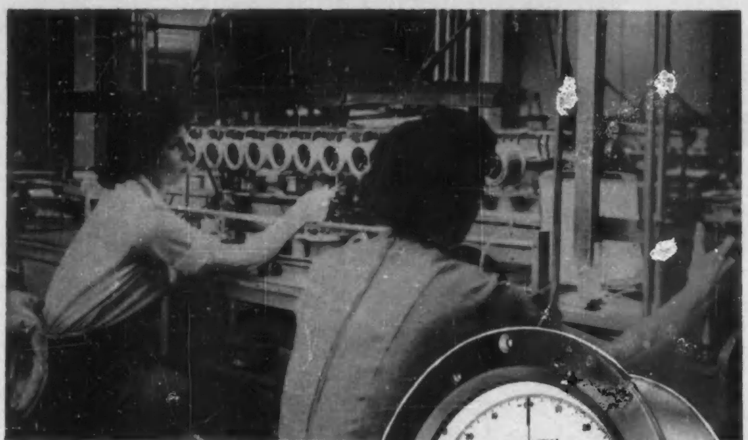
Years of specialization in the design and manufacture of "CERAMO" thermocouples enable us to offer a product of consistently high quality. Our experience with thousands of specific applications has given us a vast knowledge of the product's proper use in industry.

Find out how "CERAMO" can help improve your process controls . . .

Write for catalog 34-B

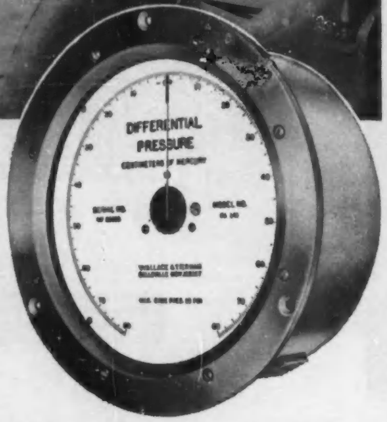
Thermo Electric CO., INC. SADDLE BROOK, NEW JERSEY

In Canada: THERMO ELECTRIC (Canada) LTD., Brampton, Ontario



▲ W&T 3" low pressure gauges, individually calibrated, are checked against a precision standard.

A 6" gauge for easy readout is also available.▶



PRESSURE MEASUREMENTS WITH PRECISION

W&T low pressure gauges bring 0.3% accuracy, rugged portability to your job

Calibration checked and double-checked . . . so you know the gauge is right when you record a reading. And W&T pressure gauges stay accurate in spite of rough handling. You can use them right on the job—still have laboratory accuracy.

These gauges are in stock now. For information write Dept. A-122.28

service: gauge pressure; differential pressure; vacuum determinations; or as compound pressure-vacuum gauges with zero center; **accuracy:** 1 part in 300; **sensitivity:** 1 part in 500; **minimum range:** 0 to 10 inches H_2O; **maximum range:** 0 to 400 inches H_2O; intermediate ranges of pressure or vacuum in any pressure equivalent are also available.

WALLACE & TIERNAN INCORPORATED
25 MAIN STREET, BELLEVILLE 9, NEW JERSEY
IN CANADA: WALLACE & TIERNAN LTD., WARDEN AVE., TORONTO 1, ONT.

CIRCLE 198 ON READER SERVICE CARD

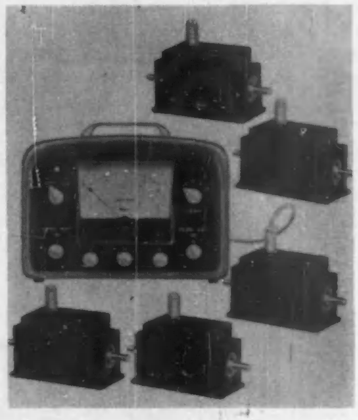
is your feeding problem peculiar to your operation?

Wallace and Tiernan's volumetric feeders are so flexible that each job is practically custom built. W&T's experience is broad enough to meet any challenge.

Try us-for information write Dept. MV-1.28

WALLACE & TIERNAN INCORPORATED
25 MAIN STREET. BELLEVILLE 9, NEW JERSEY

RESEARCH, TEST & DEVELOPMENT



MULTIPLE INPUTS

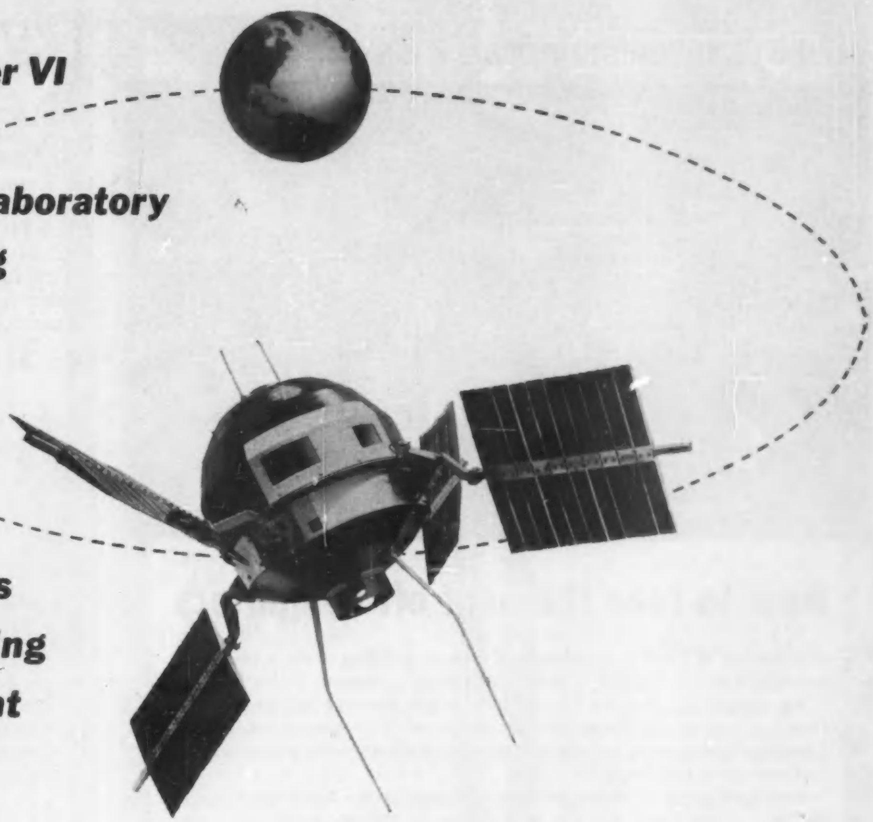
As many as five pickup heads can be used with Metron's newest torquemeter. A single selector knob couples the pickup to the meter while individual calibration knobs permit separate zero adjustment of each head. Available ranges cover torques from 0.1 to 500 oz-in. Readings are independent of shaft speeds between 50 and 24,000 rpm. Meter accuracy is said to be within 2 percent of full scale. Overall design provides protection against overloads as high as twice the rated load.—Metron Instrument Co., Denver, Colo.

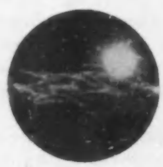
Circle No. 286 on reply card

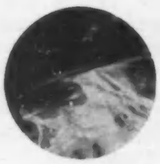
AUTOPILOT ANALYZER

Developed to provide a fast, accurate check on the performance characteristics of advanced automatic pilot systems, the Model 5800 Servoflight Autopilot Analyzer represents a specialized version of this company's servosystem analyzers. The instru-

Explorer VI is a space laboratory orbiting around the earth with paddles capturing sunlight for power







The scientific data that will some day enable us to probe successfully to the very fringes of the universe is being recorded and transmitted at this moment by the space laboratory Explorer VI, a satellite now in orbit around the earth ● This project, carried out by Space Technology Laboratories for the National Aeronautics and Space Administration under the direction of the Air Force Ballistic Missile Division, will advance man's knowledge of: *The earth and the solar system . . . The magnetic field strengths in space . . . The cosmic ray intensities away from earth . . . and, The micrometeorite density encountered in inter-planetary travel* ● Explorer VI is the most sensitive and unique achievement ever launched into space. The 29″ payload, STL designed and instrumented by STL in cooperation with the universities, will remain "vocal" for its anticipated one year life.

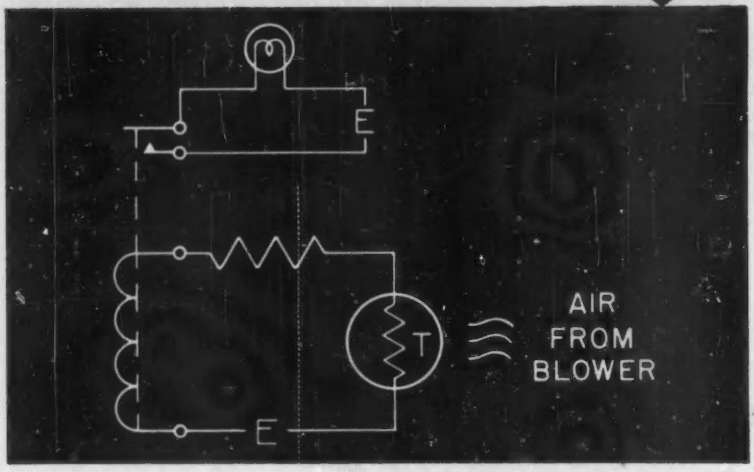
How? Because Explorer VI's 132 pounds of electronic components are powered by storage batteries kept charged by the impingement of solar radiation on 8,000 cells in the four sails or paddles equivalent to 12.2 square feet in area ● Many more of the scientific and technological miracles of Explorer VI will be reported to the world as it continues its epic flight. The STL technical staff brings to this space research the same talents which have provided systems engineering and over-all direction since 1954 to the Air Force Missile Programs including Atlas, Thor, Titan, Minuteman, and the Pioneer I space probe.

Important staff positions in connection with these activities are now available for scientists and engineers with outstanding capabilities in propulsion, electronics, thermodynamics, aerodynamics, structures, astrophysics, computer technology, and other related fields and disciplines.

Space Technology STL **Laboratories, Inc.**

Inquiries and resumes are invited.
P.O. Box 95004
Los Angeles 45, California

GLENNITE THERMISTOR DESIGN IDEAS NO. 11



How to take the heat off computers

Dissipation of heat in computers is a basic problem usually involving trouble-free blowers and a fool-proof safety system.

By employing Glennite Thermistors, some computer engineers have found a way of providing this protection with greater economy and security. Thermistors are temperature sensitive resistors with negative coefficients of resistance.

In this application, thermistors are operated in the self-heated range. As long as air flows past the thermistor, its resistance remains sufficiently high to keep the relay open. Should the blower system fail, the thermistor temperature would increase thereby decreasing in resistance. Increased current in the circuit would close the relay and turn on indicator light, turn off power or perform any other desired action.

Advantages: thermistor replaces more expensive switching device, eliminates use of moving parts—possibility of mechanical failure, proves safer, more economical.

Air flow detection is only one of many interesting applications for Glennite Thermistors. Other uses include time delay, temperature control, liquid measurement, fire control, etc.

Glennite wafer, bead and rod thermistors are available in a variety of resistance values, temperature coefficients and sizes to help you evaluate circuit problems. They may be obtained from your local distributor, or from Gulton Industries in bulk quantities.

Test Your Ideas With A Glennite Experimenter's Thermistor Kit

An inquiry on your company letterhead will make available to you a Glennite Experimenter's Kit for $14.95. For those engineers who have had some experience with thermistors, comprehensive kits are available for $49.95. For complete information, write directly to Gulton Industries, Inc.

Custom Made Thermistors To Your Specifications

Gulton will supply thermistors to your specifications with resistance values from 1 ohm to 10 megohms and temperature coefficients of resistance to −6.8% per degree C. Temperature range: −60° to +500°C.

MATERIALS & CERAMICS DIVISION, Metuchen, New Jersey

Gulton Industries, Inc.

In Canada: Titania Electric Corp. of Canada Ltd., Gananoque, Ont.

ment features self-generated test signals, direct amplitude and frequency settings, and frequency accuracy within 3 percent of the actual setting. A 3-position range selector switch provides full dial frequencies of 0.02 to 0.2 cps, 0.2 to 2 cps, 0.2 to 20 cps. Weighing only 30 lbs, the unit is well suited for field use.—Servo Corp. of America, Hicksville, N. Y.

Circle No. 287 on reply card

MAKES FIELD TESTS

Designed for field use but accurate enough for high levels of maintenance, the Type 13819-2-A test set accurately checks synchronous transmitters, receivers, servoed synchro-instruments, and synchro differentials for electrical zero and calibration and provides a functional check of low-inertia servomotors. It weighs just a little over 23 lbs. and measures 9x11x18 in. Accuracy is within 10 min of arc, and its fine dial is calibrated in 6-min. increments. Set operates on a 115-volt, 400-cycle, single phase supply.—Eclipse-Pioneer Div., of Bendix Aviation Corp., Teterboro, N. J.

Circle No. 288 on reply card

IMPROVED PERFORMANCE

An extremely sensitive miniature cam, spring loaded for positive adjustment, has replaced a potentiometer as the

BASIC
BUILDING
BLOCKS
FROM KEARFOTT

FLOATED RATE INTEGRATING GYROS

Specifically designed for missile applications, these Kearfott miniature gyros operate efficiently at unlimited altitudes. Their outstanding accuracy and performance make them superior to any comparably-sized units on the market. Hermetically sealed within a thermal jacket, these gyros are ruggedly designed and completely adaptable to production methods. Performance characteristics that are even more precise can be provided within the same dimensions.

TYPICAL CHARACTERISTICS

Mass Unbalance:
Along Input Axis: 1.0°/hr maximum untrimmed
Standard Deviation (short term):
Azimuth Position: 0.05°/hr
Vertical Position: 0.03°/hr
Drift Rate Due to Anisoelasticity
Steady Acceleration: .015°/hr./g^2 maximum
Vibratory Acceleration: .008°/hr./g^2 maximum
Damping:
Ratio of input angle to output angle is 0.2
Characteristic Time: .0035 seconds or less
Weight: 0.7 lbs.
Warm-Up Time: 10 minutes from –60°F
Life: 1000 hours minimum

Write for complete data.

BASIC
BUILDING
BLOCKS
FROM KEARFOTT

20 SECOND SYNCHRO

This synchro, just one of a broad line offered by Kearfott, provides the extreme accuracy required in today's data transmission systems. Kearfott synchro resolvers enable system designers to achieve unusual accuracy without the need for 2-speed servos and elaborate electronics. By proper impedance, matches up to 64 resolver control transformers can also operate from one resolver transmitter.

TYPICAL CHARACTERISTICS **SIZE 25**

Type Resolver	Transmitter	Control Transformer
Part Number	Z5161-001	Z5151-003
Excit. Volts (Max.)	115	90
Frequency (cps)	400	400
Primary Imped.	400/80°	8500/80°
Secondary Imped.	260/80°	14000/80°
Transform. Ratio	.7826	1.278
Max. Error fr. E.Z.	20 seconds	20 seconds
Primary	Rotor	Stator

Write for complete data.

BASIC
BUILDING
BLOCKS
FROM KEARFOTT

MINIATURE VERTICAL GYRO

Provides accurate vertical reference in the form of two 400 cps synchro signals proportional to sine of gimbals' displacement about pitch and roll axes. Gravity-sensitive vertical reference device provides electrical signals directly to torque motors which maintain gyro spin axis perpendicular to earth's surface. Hermetically sealed and impervious to sand, dust, sun, rain, salt, spray, humidity or fungus as specified in MIL-E-5272A.

TYPICAL CHARACTERISTICS

Free Drift Rate:
Within 0.5° in one minute time.
Shock:
The gyro operates satisfactorily without damage after 60g shock of .015 seconds duration.
Hermetically Sealed:
These instruments are hermetically sealed and are not affected by sand, dust, sunshine, rain, humidity or fungus conditions.
Operating Temperature Range:
Gyros operate in ambient temperatures below —20°C to +100°C. A maximum of 3 minutes of operation at 400°F will not damage these gyros nor impair their accuracy.
Weight:
5.5 lbs. approximately.

Write for complete data.

Time Index Digitalizer

Precise Angle Indicator

Size 8 Integrating Motor Generator

Engineers: Kearfott offers challenging opportunities in advanced component and system development.

Kearfott | A GENERAL PRECISION COMPANY

KEARFOTT COMPANY, INC., LITTLE FALLS, N. J.
A subsidiary of General Precision Equipment Corporation
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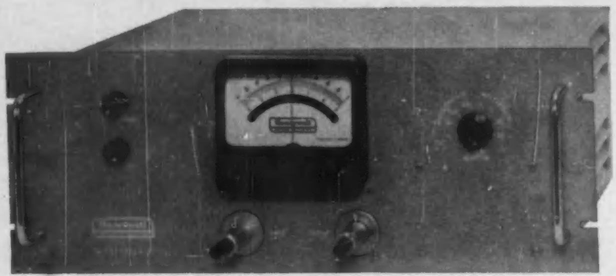
New General Purpose Amplifier

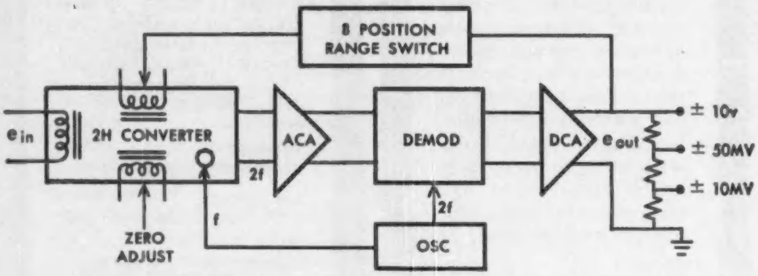
3 INSTRUMENTS IN 1



Model 2HLA-9 measures 19" wide x 7" high x 14" deep

The new Honeywell Differential Input Indicating Amplifier, Model 2HLA-9, is a general purpose, low level d-c instrument. It may be used as an ultra-sensistive null indicator, an indicating amplifier or a pre-amplifier for self-balancing recording potentiometers. Reliability, simplicity, ruggedness, plus sensitivity permit use of the Model 2HLA-9 in virtually every location where a source of 115 volts, 50 or 60 cps is available. The unit may be conveniently mounted on rack or bench.

The Model 2HLA-9 is a magnetic-electronic instrument that possesses the most desirable characteristics of both mechanical and electronic galvanometers, including high resistance to strays, overload protection and rapid response. Write for Technical Bulletin B-C2HLA-9 to Minneapolis-Honeywell, Boston Division, Dept. 34, 40 Life Street, Boston, Mass.



FEATURES

INPUTS: ±10, 30, 100, 300, 1000, 3000, 10,000, 30,000 μ volts.

ISOLATED DIFFERENTIAL INPUT: For operation at high a-c and d-c voltage above ground without error.

MAGNETIC CONVERTER INPUT: For accurate d-c to a-c conversion with minimum zero drift and high immunity to a-c ripple.

ADJUSTABLE ZERO SUPPRESSION: ±100% on 10 through 3000 μv ranges.

DRIFT: ±0.50 μ volt short term.

COMMON-MODE REJECTION: $10 \times 10^6/1$ or better at d-c, better than 250,000 to 1 at 60 cps.

OUTPUT: ±10 volts, ±50 mv and ±10 mv taps.

OUTPUT IMPEDANCE: 1000 ohms.

INPUT IMPEDANCE: Approx. 1000 ohms.

NOISE: Less than 0.1% rms 0-10 KC.

FREQUENCY RESPONSE: 3 db down at 5 cps maximum.

Honeywell

H First in Control

NEW PRODUCTS

zero adjustment device on this redesigned calibrating and weighing system balancing instrument. This design not only avoids the possibility of phase shift error, but also eliminates the need for an algebraic subtraction in obtaining the proper reading.—Morehouse Machine Co., York, Pa.

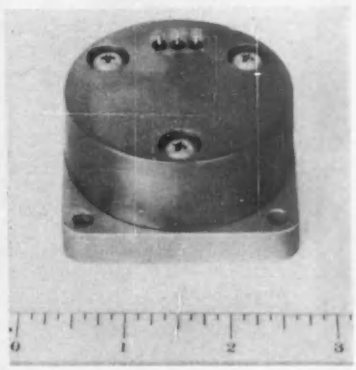
Circle No. 289 on reply card

PLUS . . .

(290) The Model NC-1200 **transistorized frequency standard**, announced by **National Co., Inc.**, Malden, Mass., features extremely stable outputs of 0.1 to 5.0 mc. . . . (291) The **Federal Scientific Corp.**, New York City, now offers a line of real time spectrum analyzers with sequential outputs. . . . (292) **Parabam, Inc.**, Hawthorne, Calif. offers a new **angle dial reader** for precision semiautomatic reading of elevation and azimuth angle dials on cine theodolite and radar data film.

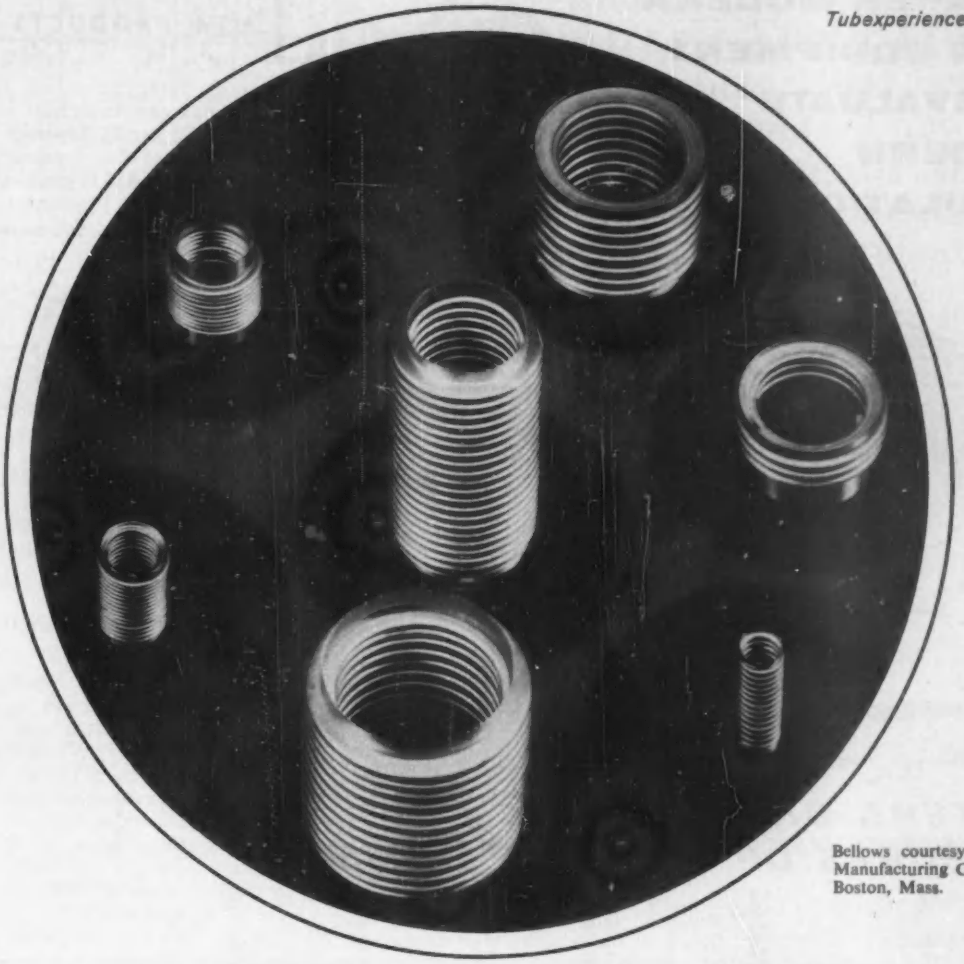
Circle Nos. 290, 291, or 292 on reply card

PRIMARY ELEMENTS & TRANSDUCERS



GAS-DAMPED

Ideally suited for aircraft and missile applications, this compact precision accelerometer contains a unique gas-damped seismic system and provides highly stable, accurate, and reliable performance in severe environments. Units are available with ranges from plus or minus 1.0 g to plus or minus 25 g. Damping is 65 percent of critical at 75 deg F. Operating tem-



Bellows courtesy Clifford Manufacturing Company, Boston, Mass.

750,000 flexures without failure

—a common performance record for bellows formed from Superior Thin-Wall Tubing

Bellows, more sensitive than spirals and better adapted to accurate measurement of pressure and vacuum, or absolute pressure in the low and intermediate range, must withstand thousands of flexures without failure. The tubing from which they are made must be highly uniform in physical and mechanical properties and must have the invariably smooth surfaces that contribute so much to good fatigue life. It must be extremely ductile—forming pressures run as high as 5000 psi. Brazing operations used to fasten it to another assembly may subject it to temperatures up to 1800°F. It must have excellent corrosion resistant characteristics. And it must be free of carburization, dents and pickups that lead to premature fatigue failure of the bellows in service.

Thin-wall tubing of this quality—usually under .010 in. max. wall thickness and held to a tolerance spread of only one-thousandth inch—requires the skills and facilities of tubing specialists. Superior maintains production standards fully in keeping, employs special handling procedures, uses special controlled-atmosphere furnaces to provide the uniformly annealed tubing demanded. Superior tubing is produced in a wide range of analyses, in both Seamless and WELDRAWN® types, and to specified IDs, ODs and wall thicknesses.

Bellows tubing is just one of many types supplied by Superior. Available are more than 120 analyses, in a wide range of sizes, and meeting almost any requirement. For a good glimpse of the field covered by Superior, send for Bulletin 41. Superior Tube Company, 2026 Germantown Ave., Norristown, Pa.

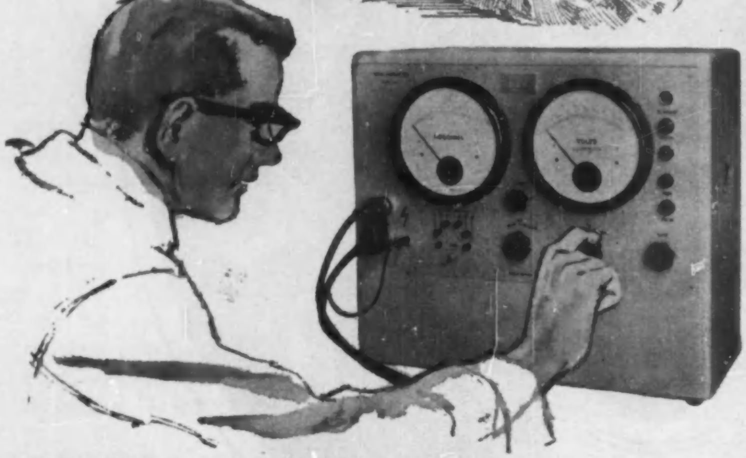
Superior Tube

The big name in small tubing
NORRISTOWN, PA.

All analyses .010 in. to ⅝ in. OD—certain analyses in light walls up to 2½ in. OD

West Coast: Pacific Tube Company, Los Angeles, California • FIRST STEEL TUBE MILL IN THE WEST

IT TAKES MODERN TEST EQUIPMENT TO EVALUATE MODERN INSULATION



ITT TERA-OHMMETER MEASURES UP TO 5×10^{15} OHMS

TYPICAL APPLICATIONS

- Leakage resistance of capacitors
- Insulation qualities of resistors, tube sockets, switches, etc.
- Test and inspection of cables
- Purity of liquids
- Surface resistance of printed circuits
- Moisture content of paper

FEATURES

- Measures from 20 megohms to 5,000 tera-ohms in 6 ranges
- Test voltage continuously variable from 100 to 1,000 volts dc
- ±3% center-scale accuracy
- Permits grounded or off-ground measurements
- Two large 7" meter scales for easy simultaneous reading of voltage and resistance
- Charge button for measuring capacitors

Write, wire, or 'phone for complete technical information.

Measuring today's special insulating materials, in the laboratory or on the line, calls for an advanced ohmmeter with far wider range and accuracy than provided by the relatively simple equipment considered satisfactory only a few years ago. Now, the ITT Type FT-H4 Tera-Ohmmeter* permits measurements of insulation resistances up to 5,000 tera-ohms, at voltages up to 1,000 volts, with ease, accuracy, and extreme stability.

In addition, the ITT Tera-Ohmmeter indicates instantaneous changes in insulation resistance. This is a particularly important advantage, not available in instruments based on the bridge or galvanometer method of measurement. Since insulation resistance is generally not a fixed value, but varies readily as a function of time, temperature, humidity, voltage, pressure, etc., the slope of the resistance/time characteristic is often more interesting to the observer than the final value obtained.

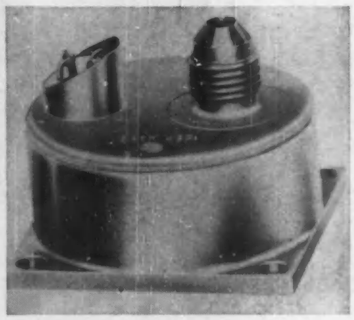
The fast response, high accuracy, extreme stability, and easy readability of the ITT Type FT-H4 Tera-Ohmmeter make it a practical necessity for production and research testing.

**Manufactured by Richard Jahre.*

ITT **Industrial Products Division**
INTERNATIONAL TELEPHONE AND TELEGRAPH CORPORATION
15191 Bledsoe Street • San Fernando, Calif. • EMpire 7-6161

perature range extends from minus 65 to plus 250 deg F. Linearity error is said to be less than 1 percent of the total acceleration span.—Wiancko Engineering Co., Pasadena, Calif.

Circle No. 293 on reply card



AVAILABLE IN 11 RANGES

A new miniature pressure transducer, the Model 725, is designed for extreme vibration environments, and available in 11 standard pressure ranges from 0-200 to 0-5000 psi. Static error band for these units, based on terminal base calibration is within 0.8 percent, dynamic error band within 1.8 percent. Optional mountings, pressure settings, and electrical connectors are available. Basic dimensions are 1-¾ in. in diameter by ⅞ in. high.—Bourns, Inc., Riverside, Calif.

Circle No. 294 on reply card

MINIATURE ACCELEROMETER

The TA-400 precision miniature accelerometer, designed for measuring linear acceleration in missiles and aircraft, is believed to be the smallest of its type in production. Only 15/16 in. in diameter and ⅞ in. long it will withstand 100 g's shock and 20 g's vibration at 50 to 2000 cps. The unit is completely filled with damping fluid, has a unique mass suspension arrangement, and features additional taps to permit a superimposed ac or dc excitation to torque the pick-up and pendu-

Philbrick introduces . . . . . . **OPERATIONAL AMPLIFIERS**

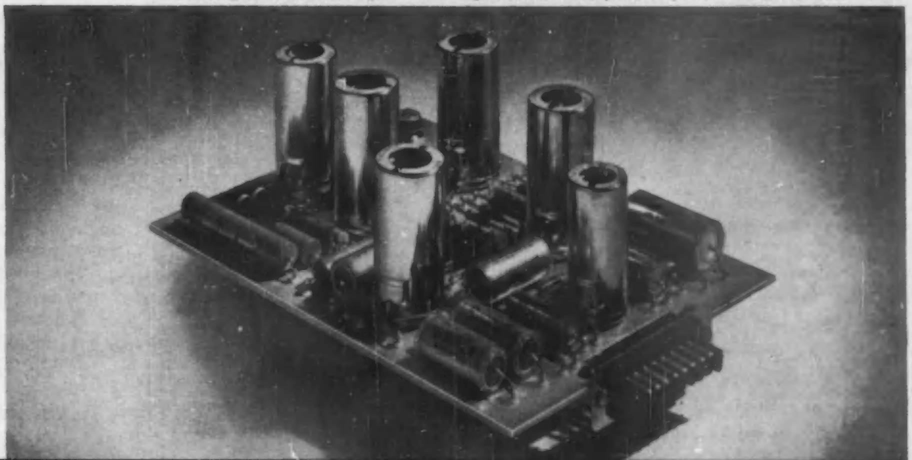
DESIGNED SPECIFICALLY FOR MILITARY APPLICATIONS

Philbrick now offers an array of dc operational amplifiers which use MIL-approved components. They are reliable and rugged to withstand all standard shock, vibration, and environmental conditions; they meet military requirements for land, sea, air, and space applications.

USA-4 JX At the present moment these units are the highest performance, coolest running operational amplifiers available in the world today, commercial or military. Drift, noise, grid current, gain, bandwidth, damping and like characteristics including predicted reliability are so much improved that this series is now also a "best buy" for critical commercial instruments. Featuring ±100 volt output, and a guaranteed minimum dc gain of 100,000,000, there are plug-in models designed for slide mounting and others using turret terminals for permanently wired-in installations. Price **$170**

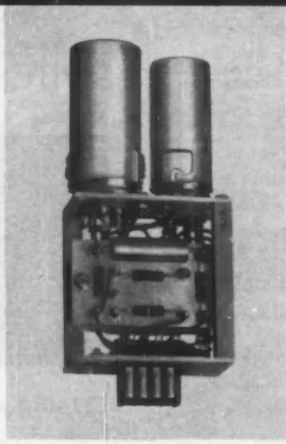
USA-4 series

- MIL-STD component parts.
- Reduced internal dissipation density
- Teflon-insulated stand-off terminals
- Machined aluminum plate with clear anodize finish
- Zero-adjust (balance) control is self contained and does not normally require readjustment
- Amplifier runs cool; tubes, resistors operate at a fraction of their wattage ratings, capacitors far below their voltage ratings

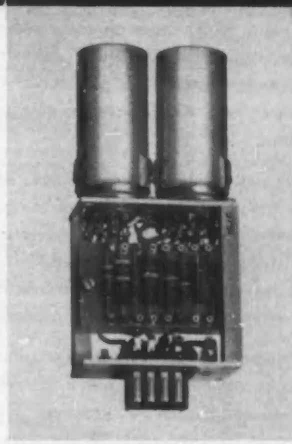


K2 series

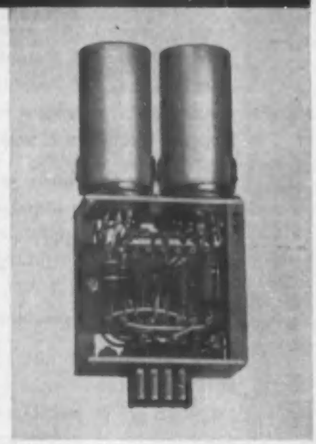
- Very low internal dissipation
- Differential inputs provided
- MIL-STD component parts
- Special open frame construction provides optimum free-air ventilation
- Epoxy glass terminal board
- Structural parts are machined aluminum with MIL-irridite finish
- Amphenol Blue Ribbon type connector
- Provisions are made for secure mounting to the chassis



K2-PJ An accurate, low drift, low frequency chopper amplifier, the K2-PJ is ideally suited to stabilizing (servoing out the drift error in) an unstabilized dc amplifier such as the K2-WJ, K2-YJ, etc. When used as a preamplifier for the K2-WJ, the pair typically exhibits a long term drift of less than 100 microvolts, zero grid current, and a dc gain of 10 million. Write for details. Price (1 thru 99) **$85**



K2-WJ An efficient, fool-proof, high gain, low cost operational amplifier for all feedback manipulations. Its differential inputs allow use either as a "follower" or as a positive sign amplifier featuring "infinite impedance" input (open grid). The guaranteed minimum gain figure of 10,000 (over 15,000 typical), ±50 volt output, and the low drift make possible a wide variety of dc and low frequency operations such as summing, amplication, function generation, integration, differentiation, voltage clipping, tripping, flipping, flopping, and the like at accuracies substantially better than 1/10%. Price (1 thru 99) **$58**



K2-YJ An operational amplifier identical in shape, size, and concept to the K2-WJ, but featuring twice the output voltage (±100v) and three times the output current (3 ma) at a sacrifice in gain. Most characteristics are also similar, including drift. Using the K2-PJ as a preamplifier for the K2-YJ, the pair becomes the coolest-running, most compact operational amplifier available which can provide ±100 volts output, chopper stabilized. Price (1 thru 99) **$62**

The analog way is the model way . . .
Write for more information on this addition to the Philbrick family of analog computors, components, and power supplies.

GEORGE A. **PHILBRICK** RESEARCHES, INC.
285 COLUMBUS AVENUE, BOSTON 16, MASSACHUSETTS

This stepping motor, when suitably pulsed, has a torque output of 1 inch-ounce, in steps that are never more, never less than 18°. Each one is produced by a half cycle or a current reversal. Consequently it is very useful for converting electrical numbers to mechanical numbers, and has been sold for this purpose for some time (the Sigma "Cyclonome"®).

In the trick mirror is a servo motor which stops on command with perfect obedience, because it stops every little while anyway, delivering torque in 18° quanta. The 20-tooth ratchet sensation is produced by a fiercely discontinuous permanent magnet field, which develops going and stopping torques of 1 inch-ounce.

So, here is a positioning servo motor which is synchronous and has a mechanical time constant of $\frac{1}{4}$ cycle. Effective ratio of torque to inertia, with regard to coasting, is *infinite*—as long as these parameters are respected:

inertia (gram-cm^2) x (steps/sec.)^2 $\leqq$ 180,000, and
steps/second $\leqq$ 300, assuming direct drive to mechanical load.
(Otherwise, you have a synchronous motor of unspecified nature.)

Since any reduction ratio is squareable (we wish it were cubable) a ratio of 10:1 permits an inertia of 200 gram-cm^2 to be driven at three-hundred 1.8° steps per second. Useful torque is then 700 gram-cm. Think of it—*6 incb-pounds* per second, for only 10 or 15 watts. While there is a relation between power and speed, there is *no relation between torque and speed.* Torque is proportional to input current (up to saturation), speed to input frequency.

If you will write on your letterhead, you will receive an engineering bulletin describing the simple Cyclonome discussed above, as well as the reversible model.

Merry Christmas - Art Dept.

SIGMA INSTRUMENTS, INC.
69 Pearl Street, So. Braintree 85, Massachusetts
An Affiliate of The Fisher-Pierce Co. (since 1939)

lum in either direction from null. It will measure accelerations from plus or minus $\frac{1}{2}$ g to plus or minus 50 g and has an undamped natural frequency range of from 10 to 175 cps.—Fairchild Controls Corp., Hicksville, N. Y.

Circle No. 295 on reply card

PLUS . . . .

(296) **Gulton Industries, Inc.**, Metuchen, N. J., has developed a light weight donut shaped **accelerometer** for laboratory or in-flight shock and vibration measurements. . . . (297) An instrument which **calibrates the thickness of ice** on liquid oxygen tanks during static missile testing firings has just been announced by **Task Corp.**, Anaheim, Calif. . . . (298) A low range **pressure transducer**, introduced by **Taber Instrument Corp.**, North Tonawanda, N. Y. features a 1 millisec. response time in measuring liquid or gas pressures up to 50 psi.

Circle No. 296, 297 or 298 on reply card

CONTROLLERS, SWITCHES, & RELAYS

RELIABLE SCANNING

Mounted in modularized packages, the new Scanalog series of multipole sampling switches has been designed for high speed scanning of both high and low level analog voltages and currents and conforms fully to military environmental specifications. Multiple contact wipers, designed for low level signal sampling, are mounted on the output shaft which is driven through precision gears. Model shown above is a 3-pole, 30-channel Scanalog suitably sealed and ready for installation.—Fifth Dimension, Inc., Princeton, N. J.

Circle No. 299 on reply card

CHECK YOUR PULSE, SIR?

"SCOTCH" BRAND High Resolution Tapes

deliver a sharper pulse—with fewer dropouts!

In instrumentation, as in life, it's often the pulse-count that counts. So what if your recording impulses are as square as a bar-graph? If your tape only records camel-backed humps, where are you? Probably about due for a change—to "SCOTCH" BRAND High Resolution Tapes.

Your equipment is somewhat like the proverbial sweater—no matter how advanced, you can only get out of it what you put in. And that calls for "SCOTCH" BRAND High Resolution Tapes—made to deliver improved resolution as pulse density climbs and effective frequencies soar upward to stratospheric heights.

Like so many other advances in tape technology, this superior resolution is a product of 3M research. For one thing, "SCOTCH" BRAND high potency oxides give coatings a higher magnetic retentivity—about a third more than standard. And since the shorter wave lengths of high frequencies are recorded by the surface of the coating, a coating of these potent oxides can be thinner and yet provide equal flux line strength. Results? A flexible tape for intimate tape-to-head contact, a cleaner, sharper recorded pulse.

"SCOTCH" BRAND High Resolution Tapes offer these potent coatings on your choice of two tough polyester backings—158 for standard play, 159 for extra-play. And both are designed to line up your square-waves as densely as a close-order drill, so sharp and clean you'll never miss a bit.

In taping high frequencies, the tested uniformity and dropout-free performance of "SCOTCH" BRAND Magnetic Tapes give the added bonus of reliability. The greater the density of information, the more critical the need for defect-free tapes, and here's where experienced "SCOTCH" BRAND Tape technology really tells.

Whatever your application—data acquisition, reduction or control programming—"SCOTCH" BRAND Instrumentation Tapes supply the reliability you need today and continue to anticipate tomorrow's needs with newer, more sensitive tapes.

In addition to "SCOTCH" BRAND High Resolution Tapes 158 and 159, check the others for your application. "SCOTCH" BRAND High Output Tape 128 offers top output in low frequencies, even in ambient temperature extremes. "SCOTCH" BRAND Sandwich Tapes 188 and 189 end rub-off, build-up, reduce head wear to an absolute minimum, show little wear after 50,000 passes. "SCOTCH" BRAND Instrumentation Tapes 108 and 109 remain the leaders for top performance at low cost.

Where there's no margin for error, there's no tape like "SCOTCH" BRAND Magnetic Tape for instrumentation. For details, write Magnetic Products Div., Dept. MBS-129, 3M Company, St. Paul 6, Minn. or mail the inquiry card. © 1959 3M Co.

"SCOTCH" is a registered trademark of 3M Company, St. Paul 6, Minnesota. Export: 99 Park Avenue, New York, N.Y. In Canada: London, Ontario.

SCOTCH BRAND MAGNETIC TAPE

FOR INSTRUMENTATION

MINNESOTA MINING AND MANUFACTURING COMPANY

... WHERE RESEARCH IS THE KEY TO TOMORROW

3M COMPANY

HEISE GAUGES

Indoor Oil Well

Pressures up to 20,000 psi at temperatures to 350 degrees F., encountered deep in the earth, are reproduced under laboratory control by the Continental Oil Company in testing cement slurries for use in oil well cementing.

Temperature and pressure are increased according to "Well Simulation Schedules" until the desired conditions are reached and are then held to ± 2 degrees F. and ± 10 psi to the completion of the test.

The Heise Gauge is featured in the Stanolind-Type Super Pressure Consistometer built for this work by the Refinery Supply Company, a Central Scientific Company affiliate.

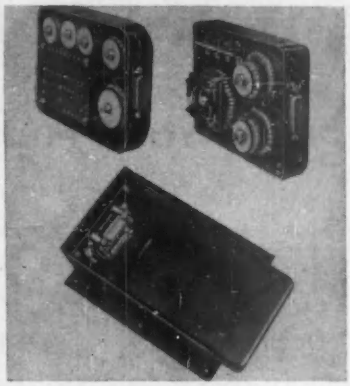
Four years of accurate, trouble free performance under these extreme conditions attest the value of the Heise Gauge as a dependable precision instrument.

Pressure Ranges 15 to 20,000 P.S.I. Dial Sizes 8½"-12"-16"

Prices from $166.75 **DELIVERY WITHIN 30 DAYS**

HEISE BOURDON TUBE COMPANY, INC.

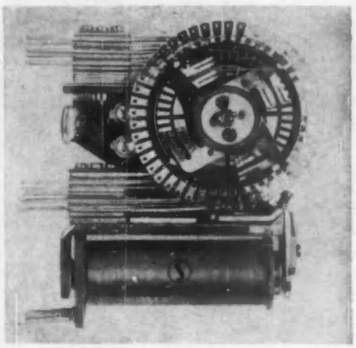
BROOK ROAD, NEWTOWN, CONNECTICUT, U.S.A.



MODULAR CONTROL

Suitable for aircraft and missile systems, this modular control package consists of a magnetic preamplifier, magnetic power amplifier, and a common housing. Quick connect-disconnect plugs facilitate removal of either amplifier. Unit contains no moving contacts or relays and will drive motors rated at up to 200 watts. Preamp weighs 0.8 lbs. and has a gain of 200 v/v and a power output of 18 mv. Corresponding characteristics in the power amplifier are 1.15 lbs., 6.5 v/v, and 27 watts.—Airborne Accessories Corp., Hillside, N. J.

Circle No. 300 on reply card



RELAY AND SWITCH

This versatile device combines the functions of three reliable components: a standard relay with knife-edge armature pivot operating contact springs and a rachet and pawl-driven stepping mechanism, a rachet-driven rotary switch consisting of four banks of twelve points each with sliding bifurcated spring wipers, and a rachet-driven stepping relay with two cams which open and close double contact-

JOURNAL OF APPLIED CONTROL DEVICES THAT NEVER WEAR OUT

For Control Engineers Who Are Wearing Out Before Their Time

THEY TOOK ADVANTAGE OF (NO MAINTENANCE) STATIC CONTROL

Cutler-Hammer, Inc. and Arthur G. McKee & Co., American experts at control system and steel mill design, respectively, have just paid due respect to the problem of servicing complex automatic equipment in a foreign land thousands of miles away. They have installed CONTROL Switching Reactors and Transductors in the blast furnace automatic charging control designed for an Argentine steel company. Why? Because under normal operation, CONTROL Switching Reactors simply don't wear out! Yet look what they do: (1) They sequentially count charges and other functions and register this information on the operator's control panel; (2) through logic switching, they control and interlock the static skip hoist drive, the blast furnace large and small bell actuators, the automatic coke charging system, and the alarm system . . . tying them all into the operational cycle of the blast furnace. *This is static control, so named because Switching Reactors have no moving parts. Totally enclosed, these high permeability magnetic devices operate in the gritty, corrosive atmosphere of the steel mill with never a shutdown for maintenance. Want details? Write us.*

THREE LITTLE WORDS—*logic, switch, operate*

If you want some insight into Cutler-Hammer's insight, there are three words (above) to pay special attention to. *Logic:* CONTROL's Switching Reactors are designed to take a variety of input signals to be fed into several isolated control windings and thus provide AND, OR, NOT, MEMORY and TIME DELAY sequences. *Switch:* Orthonol® cores provide stiff snap action going from "off" to "on" states. The power switching ratio is 2500:1, even under 10% over-voltage conditions. *Operate:* There's no need for auxiliary hardware. CONTROL reactors directly operate such loads as solenoids, motor contactors and magnetic clutches. They're ideal for the solid state thyratron. They handle single loads up to 300VA. *We have an engineering bulletin, giving full details on the CONTROL reactor which drives the solid state thyratron. Write for a copy.*

STATIC CONTROL:

simple and standard

From where do your signal pulses come? Limit switches? Push buttons? Relays? Any transducer with an electrical output? The CONTROL Switching Reactor compiles them, remembers them, and then acts (logically) when the right one comes along. It's a selective device, for by presetting it, you will insure its operating only upon the proper combination of signals. The result? A CONTROL Switching Reactor will replace a relay system, and once replaced, you minimize maintenance and other old-fashioned worries. *And there's a size for every need up to 300VA output. There are CONTROL reactors which operate from standard line voltages, others which deliver standard load voltages, and now there's one which takes 120 volts in and gives 120 volts out! Full details? Your copy of our catalog awaits your request.*

CONTROL Switching Reactors in Cutler-Hammer system

Reliability begins with CONTROL

A DIVISION OF MAGNETICS, INC

DEPT. CE-77 BUTLER, PENNSYLVANIA

 CIRCLE 151 ON READER SERVICE CARD

STILL THE MOST ACCURATE SIZE 11 RESOLVER

in a new, shorter mechanical construction

Without sacrifice of its unique 0.03% functional error and at significant reduction in cost to purchasers, the DIEHL B 11R 9-1 Resolver is now available in an over-all length of only 2.25″.

Complete mechanical redesign of the unit has provided this length and cost reduction together with optional provision for a rear shaft extension. Terminal connections are available either with leads (as illustrated) or soldering lugs.

In addition to a standard line of low and high impedance (compensated or uncompensated) windings the unit can be obtained with special windings for operation at frequencies as high as 2 megacycles.

A still shorter unit, 1.750″ in length, is available with the same 0.03% functional error but with comparatively lower impedances.

We invite engineers seeking to design more accurate computers to ask us for full details about these exceptionally precise new resolvers.

Diehl†

DIEHL MANUFACTURING COMPANY

A SUBSIDIARY OF THE SINGER MANUFACTURING COMPANY

Somerville, New Jersey

SINGER* MILITARY PRODUCTS DIVISION

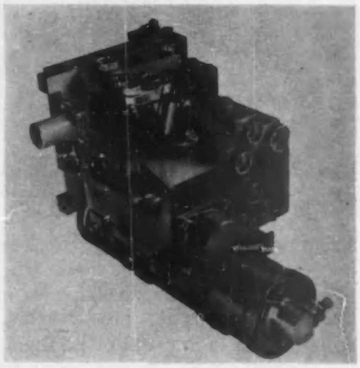
†A Trademark of THE DIEHL MANUFACTURING COMPANY *A Trademark of THE SINGER MANUFACTURING COMPANY

• AC SERVOMOTORS • AC SERVOMOTORS WITH AC TACHOMETERS • DC SERVO SETS
• AC SERVOMOTORS WITH DC TACHOMETERS • AC AND DC TACHOMETERS • RESOLVERS

type springs in accordance with the pattern. Standard 4-watt or sensitive 2-watt coils, with voltage ratings from 2 to 110 vdc, are available for either high or low speed operation. Units are suited for sequencing, counting, programming, and remote control applications.—Schrack Electric Corp., New York City.

Circle No. 301 on reply card

ACTUATORS & FINAL CONTROL ELEMENTS



ROCKET ENGINE CONTROL

This fully integrated hydraulic control package accepts electrical and pneumatic input signals and controls flow to six exterior ports and two manifolds servovalves by means of five special slide valve assemblies. Designed for operation at 3,000 psi, the package also includes a manifold accumulator, a system filter, four additional filters to protect the servovalves, three control orifices, and two check valves. This unit is currently in use on a production ICBM.—Hydraulic Research & Mfg. Co., Burbank, Calif.

Circle No. 302 on reply card

HOLDS HIGH VACUUM

A normally-closed solenoid valve, specifically designed for high vacuum service, provides lead free operation and high flow conductance by means of a unique O-ring seat seal and a straight-through design. Stem leakage is eliminated since the moving member is entirely enclosed within the valve body. Models are available for

for Gas Chromatography

An *ElectroniK* recorder designed specifically for this demanding application

Apply *ElectroniK* precision and dependability to your gas chromatography measurements with this highly accurate recorder. It's *designed specifically* for gas chromatography—includes *only* necessary parts and functions.

Some of its outstanding features:

- **Easy range-changing**
- **Continuous standardization**
- **High-resolution, linear slidewire**
- **Retransmitting slidewire . . . can be field-mounted for integrator use**
- **Low-inertia pen carriage . . . for greater sensitivity and resolution**
- **Adaptable for any type auxiliary switch and alarm**

With this recorder comes the valuable plus you get with all Honeywell instruments—prompt, expert service . . . service you can depend on, in emergencies or any time, to protect your instrumentation investment.

For complete details on the gas chromatography recorder, call your nearby Honeywell field engineer. He's as near as your phone.

MINNEAPOLIS-HONEYWELL, Wayne and Windrim Avenues, Philadelphia 44, Pa.

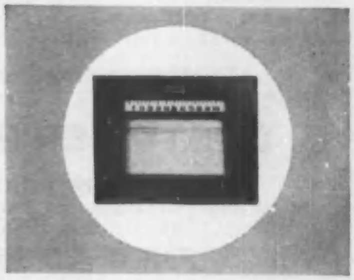


Chart speeds: ½, 1, 1½ and 2 inches per minute. Pen speed: 1 or 2 seconds full scale. Spans from 1 millivolt full scale.

Honeywell

H HONEYWELL *First in Control*

CIRCLE 153 ON READER SERVICE CARD

how HIGH is "high reliability"?

here's sheer torture for a Pot!

PROBLEM: Preco Inc. needed a high reliability, pendulum-actuated sector potentiometer for its Automatic Blade Control to serve as the reference for controlling the transverse slope of the cutting blade in road-grading equipment. The pot would be subjected to operating conditions rarely encountered even in the most severe military applications. In addition, no technical assistance would be available for maintenance or replacement.

SOLUTION: Using precious metal alloy wire, a specially formed mandrel and a precious-metal wiper assembly, Fairchild engineers developed an extremely high resolution pot which has performed effectively through more than 30 million cycles with a linearity of 0.15% and a resolution of 0.5 miliradian. Another example of Fairchild ability to custom tailor precision potentiometers and sensing devices to solve complex problems over a wide range of applications.

CUSTOMER'S TEST RESULT

Other designs failed after only 2 months' wear

FAIRCHILD'S POT has exhibited an equivalent of 5 to 10 years' life

RELIABILITY INSIDE THE BLACK BOX

FAIRCHILD CONTROLS CORPORATION

COMPONENTS DIVISION Dept. 34C

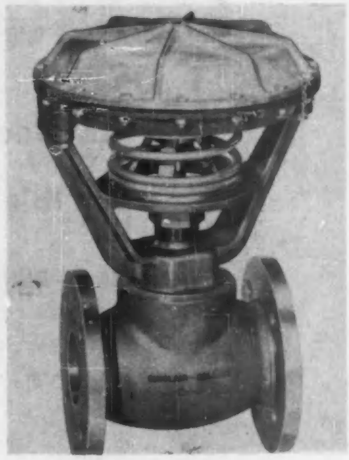
225 Park Avenue Hicksville, L. I., N. Y. • 6111 E. Washington Blvd. Los Angeles, Cal.

A Subsidiary of Fairchild Camera and Instrument Corporation

GYROS
PRESSURE TRANSDUCERS
POTENTIOMETERS
ACCELEROMETERS

$\frac{1}{2}$-in. pipe connections or for placing in $\frac{3}{4}$-in. O. D. lines. Coils are rated for continuous duty at 115 vdc and draw a hold current of 0.5 amps.—Veeco Vacuum Corp., New Hyde Park, N. Y.

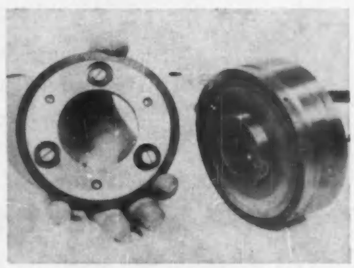
Circle No. 303 on reply card



DIAPHRAGM-OPERATED

A new line of diaphragm-operated vacuum valves, designed for applications requiring high flow rates and positive sealing, features synthetic O-ring seat seals combined with direct metal-to-metal seat stops. Units are capable of sealing and holding vacuums to within 0.5 in. Hg absolute for an indefinite period of time. Both flange and screw-mounted bodies are available.—The Sinclair-Collins Valve Co., Akron, Ohio.

Circle No. 304 on reply card



HIGH TORQUE CLUTCHES

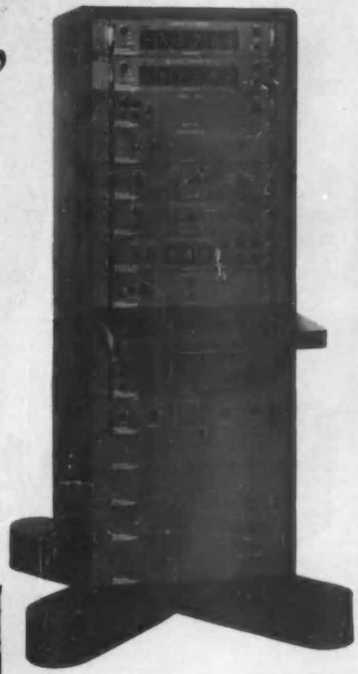
Photo shows one of a new series of face-tooth clutches, available in five torque ratings from 30 to 725 lb-ft. According to the manufacturer, these units provide the highest torque in the smallest space of any commer-

ELECTRO INSTRUMENTS can meet your systems needs NOW... with HARDWARE, NOT PROMISES!

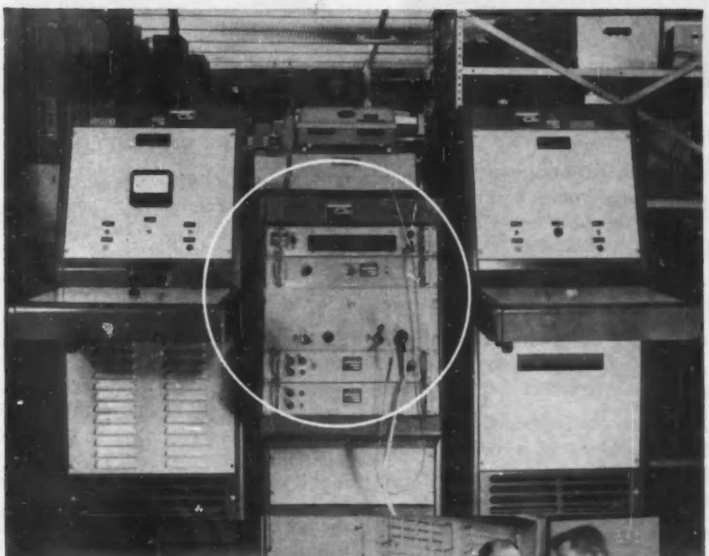
Systems shown here are typical of more than 200 designed and built by EI and now in use. They range in complexity from data logging systems for automatic scanning, measurement and recording of data from multiple transducers...to high speed, automatic checkout systems for missile and aircraft...to systems for automating industrial processes.

Because of the EI modular design approach, many of these systems can be delivered on virtually an off-the-shelf basis, eliminating the long delivery times usually associated with system development. This approach also results in a low cost system because the modules are manufactured in large quantities. Cost is almost a linear function of performance capabilities desired.

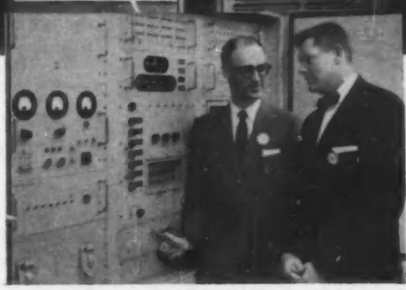
Why not talk over your digital system requirements with your EI Sales Engineer? His system experience will be a valuable help in solving your problem.



Multi-purpose digital system for measuring a variety of transistor parameters while the transistors are being subjected to environmental testing.



Digital read-out sub-system of a large, automatic, transistor production checkout system.



Sub-system for the ground support equipment on the B-58 Hustler program. Measures AC and DC single-ended voltages and ratios, and AC and DC differential voltages and transients. Chosen for its excellent operating characteristics under adverse environments.

you get MORE with EI systems!

MORE VERSATILITY—AC and DC voltages, AC and DC voltage ratios, ohmic resistances, capacitance, frequency, phase, inductance, time, or combinations of these basic input quantities can be accepted by the EI system.

MORE RELIABILITY—Maximum use is made of solid-state and MIL-type components which are designed into conservatively-rated, field-proven circuits. All vendor-supplied parts are exhaustively tested and evaluated.

MORE FLEXIBILITY—Expansion of the EI system can be made by simply adding appropriate new modules. This approach eliminates new engineering development costs each time needs change; minimizes system obsolescence.

Electro Instruments, Inc. E I 3540 AERO COURT SAN DIEGO 11, CALIF.

DIGITAL INSTRUMENTS FOR MEASURING AC/DC VOLTAGES, AC/DC RATIOS, RESISTANCE, CAPACITANCE, AND FREQUENCY • X-Y RECORDERS & ACCESSORIES • DC AMPLIFIERS

Now you can record test data on-the-spot. In both lab and field you get accuracies equal to or better than big, rack mounted units. Just pick up and move a multi-channel (up to 14) PI tape recorder/reproducer as you would any other item of test equipment.

Instead of 1,000-lb. cabinets, requiring 1000 watts, you're working with recorders 10 times smaller and lighter, using 250 watts or less.

In the field, you get laboratory performance under the most difficult environments. PI fits many places where 19-inch racks won't go. One man can carry a rugged PI recorder to virtually any test site.

How did PI put precision in a small package? By combining transistorized electronics with unique stacked reel tape magazines. PI recorders use standard tapes and heads, are compatible in every way with standard recording practices and other recording equipment.

KEY SPECIFICATIONS (Model PS-207 Series unit)

FM SYSTEM: Frequency response ±1/2 db 0-10 kc, S/N ratio 43 db, better than 1.5% total harmonic distortion, less than 2% drift 40° to 120° F., linearity 1%.
DIRECT SYSTEM: Response ±3 db 50-100,000 cps.
POWER: 115 vac, 48-62 cps or 24 vdc.
FLUTTER: Less than 0.1% rms dc to 300 cps or .5% peak-to-peak at 30 ips.
PS-207 shown contains electronics for 7 record/reproduce channels.

After you note these key specs, may we suggest you call your PI representative to arrange a demonstration? If you are uncertain who he is, please write direct. Address Dept. C 12.

Precision Is Portable

PRECISION INSTRUMENT COMPANY
1011 COMMERCIAL STREET • SAN CARLOS, CALIFORNIA • PHONE: LYTELL 1-4441

3

cially available stationary field clutches. Since there are no air gap adjustments to be made and no slip rings or brushes to be cleaned or replaced, maintainence is virtually eliminated. The fine-tooth profile on both the armature and field face assures consistent performance and minimum backlash.—I-T-E Circuit Breaker Co., Philadelphia, Pa.

Circle No. 305 on reply card

COMPONENTS AND ACCESSORIES

ELIMINATES AN AMPLIFIER

This Model 10061 millivolt controlled subcarrier oscillator will accept the output of low level transducers such as thermocouples, strain gages, and accelerometers, without external dc amplification. Instead, it contains within itself all the functions of a low level dc balanced input amplifier along with those of a superior subcarrier oscillator. With its internal voltage regulator, the unit requires only a single 26-volt supply. Its high dc common mode rejection and floating input terminals permit applications in bridge circuits for measuring the voltage between two points.—Hoover Electronics Co., Tomonium, Md.

Circle No. 306 on reply card

NEW CONTROLLED RECTIFIER

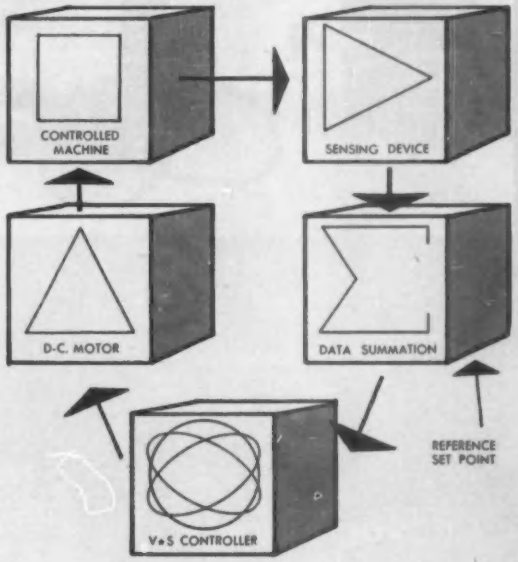
Five new inverter-type silicon controlled rectifiers are now available for such applications as dc-to-ac inversion, dc static switching, pulse width modulation, power equipment frequency conversion, and current limiting circuit breaking. These new models feature a maximum 12-μsec turn-off time at their highest rated junction temperature, and are available in peak in-

Reliance Super 'T' V★S Drives

Automatic process control from standard off-the-shelf components

Complex control systems are easily designed using the Reliance V★S Building Block Approach. Off-the-shelf components can be combined in wide variety to perform a diversity of precise control functions. The control of speed, torque and horsepower . . . the synchronization of motor speeds through feedback systems . . . and the accurate sensing devices that make precise control possible are an integral part of the V★S system.

Pneumatic, hydraulic and electric sensing equipment—such as pressure gauges, photo electric cells, level indicators, or strain gauges can be tied directly to V★S Drives. Many single-point and point-to-point numerical and digital systems have also been designed around these V★S Drives.



Typical V★S System Using Building Block Approach

Fast—Stepless—Wide Speed Range

V★S Drive components consist of a d-c. drive motor, packaged motor controls and operator's control station. Operation is from in-plant a-c. circuits. You need only the drive motor at the machine . . . controls can be placed at any convenient location.

High response Reliance drive motors change speed over a wide range, smoothly and without steps. Selections are infinite. All-electric V★S design permits inclusion of dynamic or regenerative braking for fast stopping.

A motor-generator set forms the nucleus of the motor control unit. Built-in controls regulate voltage and current in the system. You can get any required combination of speed, horsepower, torque and time characteristics.

And New Super "T" V★S Drive Now Gives You More Power in 35% Less Space!

Through use of Class B insulation—better ventilation and new NEMA re-designed a-c. and d-c. machines, more power is packed into sharply reduced space. *And this V★S Drive will take 100% overloads for one minute duration without failure.*

Reliance Super 'T' V★S Drives can be custom designed to meet your specific needs.

Reliance Sales Engineers are always available to work with you. Call your nearest Reliance sales office or write for Bulletin D-2506.

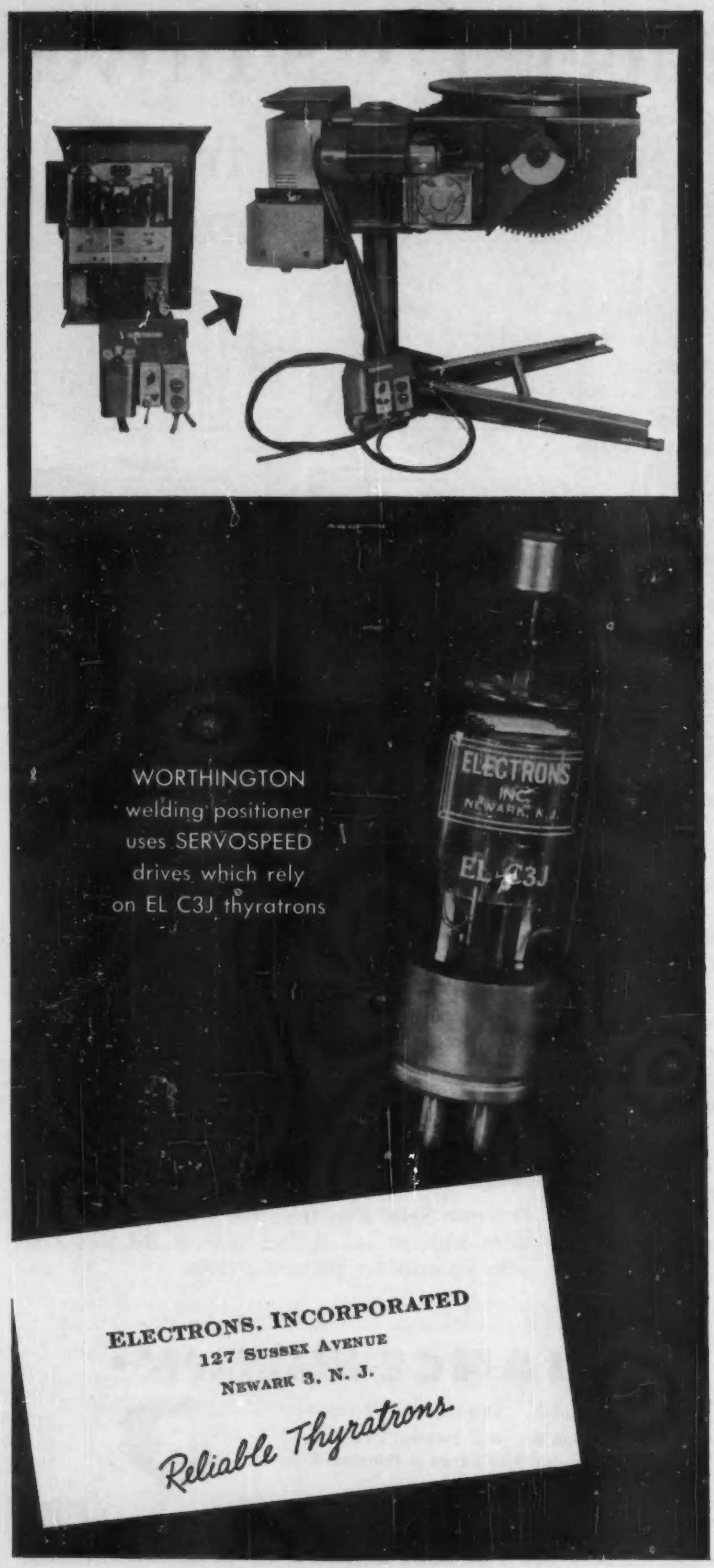
D-1048

Product of the combined resources of Reliance Electric and Engineering Company and its Master and Reeves Divisions

RELIANCE ELECTRIC AND ENGINEERING CO.

DEPT. 5212A, CLEVELAND 17, OHIO
Canadian Division: Toronto, Ontario
Sales Offices and Distributors in Principal Cities

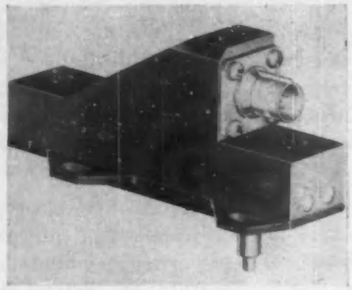
Duty Master A-c. Motors, Master Gearmotors, Reeves Drives, V★S Drives, Super 'T' D-c. Motors, Generators, Controls and Engineered Drive Systems.



NEW PRODUCTS

verse voltage ratings of 100, 150, 200, 250, and 300 volts. Units can handle continuous average forward currents up to 16 amps and reverse recovery currents to 20 amps for fast turn-off. Like the earlier conventional models, these new units have a typical gate-current-to-fire of 10 ma at 1.5 volts.—General Electric Co., Liverpool, N. Y.

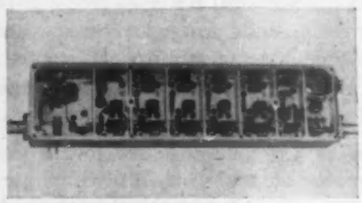
Circle No. 307 on reply card



SIDE-ACTUATED

Photo shows one of two new side-actuated precision potentiometers, offering stroke lengths of 1.890 and 2.850 in. Both types are well suited for missile control surface feedback applications because of their long life and low noise characteristics when subjected to high-frequency dithering. Features include excellent resistances to shock, acceleration, and vibration; virtually infinite resolution; and independent linearity within 0.5 percent.—Markite Products Corp., New York, N. Y.

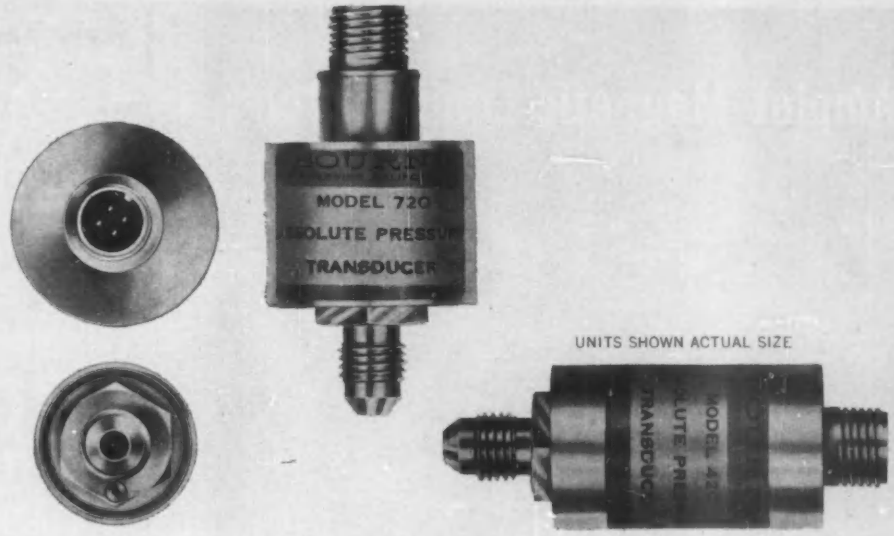
Circle No. 308 on reply card



HYBRID AMPLIFIER

Photo above shows the latest addition to the LEL Series 80 transistorized IF amplifiers. This hybrid unit combines the low noise properties of a vacuum tube input circuit with the low power requirements and ruggedness of transistors. Type 7077 subminiature ceramic triode followed by five silicon tetrode transistors provides a unit capable of withstanding high shock and vibration. Noise figure is better than 2.5 db.—LEL, INC., Copiague, N. Y.

Circle No. 309 on reply card



UNITS SHOWN ACTUAL SIZE

Bourns Pressure Transducers

SUBMINIATURE SIZE

HIGH RELIABILITY

These rugged miniaturized instruments weigh less than 4 ounces. Nevertheless, each unit is built to the same uncompromising standards that have won a place in every major missile program for Bourns instruments. At ±35G vibration, these compact instruments deliver a high level, low error, noise-free signal. Available in absolute or gage pressure versions, over a wide pressure range, the 420 and 720 lines will meet your most exacting performance and reliability requirements. These units, with a wide selection of mountings, pressure fittings and electrical connections, illustrate Bourns' ability to translate the most stringent requirements into high-performance transducers you can depend upon. They prove the statement—*in pressure transducers . . . it's Bourns for leadership.*

Specifications

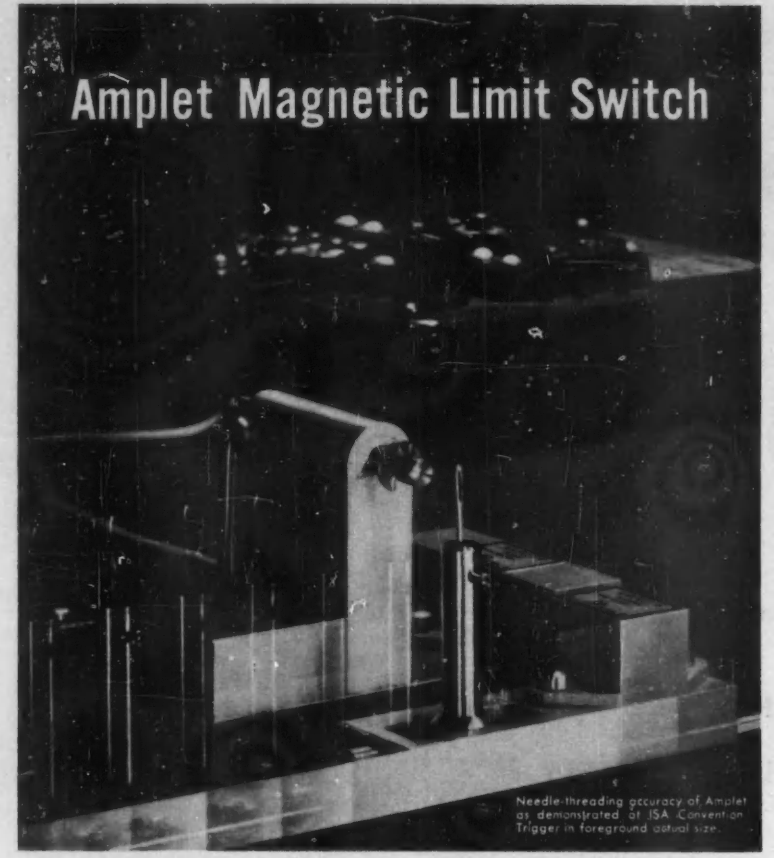
	Model 420	Model 720
Pressure ranges	0-15 to 0-350 psi	0-350 to 0-3500 psi
Operating temperature	−65 to +165°F	−65 to +165°F
Static error band	1.0 to 1.3%	1.0 to 1.3%
Dimensions	1.0″ x 1.6″	1.31″ x 1.25″
Weight	4 ounces	4 ounces

Write for complete technical data

BOURNS

Bourns, Inc., Instrument Division
6135 Magnolia Ave., Riverside, Calif.
Field Engineering Offices:
Huntington Station, L.I. and Dallas, Texas
Pioneers in potentiometer transducers for position, pressure and acceleration. Exclusive manufacturers of Trimpot®, Trimit®, E-Z-Trimit®.

CIRCLE 159 ON READER SERVICE CARD



9 times more accurate than conventional proximity systems

This new Amplet® Magnetic Limit Switch operates with uncanny accuracy . . . 9 times more accurate than conventional proximity systems. It acts on the proximity of two miniature sensing elements . . . and provides a new standard for precision control of all types of machine motion.

Amplet meets the most rigid specifications for long life, environmental conditions and continuous accuracy. Check these important features . . . • High repeat accuracy, to ±.001" on successive approaches • Adjustable differential as low as .002" • Differential accuracy is maintained within ±.001" • True snap action . . . 1 millisecond response time • Nothing to wear out, static devices are used throughout • Trigger distance variable from .020 to .200" for "on" signal, greater distances available on special order.

Amplet has only three basic parts. A probe mounts on a stationary part of the machine, a magnetic trigger mounts on the moving part and becomes the actuating element, and the amplifier boosts the probe signal to useful levels. Probe and trigger are completely free from environmental and shock conditions.

APPLICATIONS

The Amplet Magnetic Limit Switch can handle a wide variety of motion control:

- **Machine Tools — Limiting cuts or traverse on shaper, planer, automatic drill press.**
- **Transfer Machines — Position stop on multi-station transfer conveyor.**
- **Automated Production — Continuous sequencing and counting.**
- **Measurements — Automatic weighing and filling.**

FIND OUT ALL ABOUT THE NEW AMPLET . . . . Complete specifications, application information and sensitivity characteristics are available for you now. Call or write, today.

CONSOLIDATED CONTROLS CORPORATION / A SUBSIDIARY OF CONSOLIDATED DIESEL ELECTRIC CORPORATION

CC9-1

BETHEL, CONNECTICUT

NEW PRODUCTS

LOW COST ALLOYS

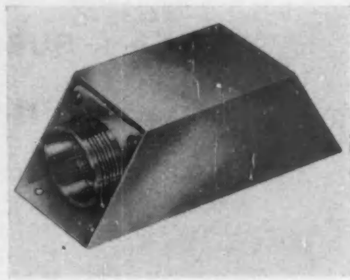
Alloy 815-R, a new low density precision resistor material, is a modified iron - chromium - aluminum composition with small percentages of several other elements. Lab tests and field applications have shown that its corrosion resistance is equivalent to that of a more costly 80-20 nickel-chromium alloy.

Characteristics:

Resistivity: 815 ohms/cmf at 20 deg C
Temperature coefficient: 0.00001 ohms/ohm/deg C
Temperature range: minus 65 to plus 150 deg C
Density: 0.262 lb/cu in.

—Hoskins Mfg. Co., Detroit, Mich.

Circle No. 310 on reply card



MEETS MILITARY SPECS

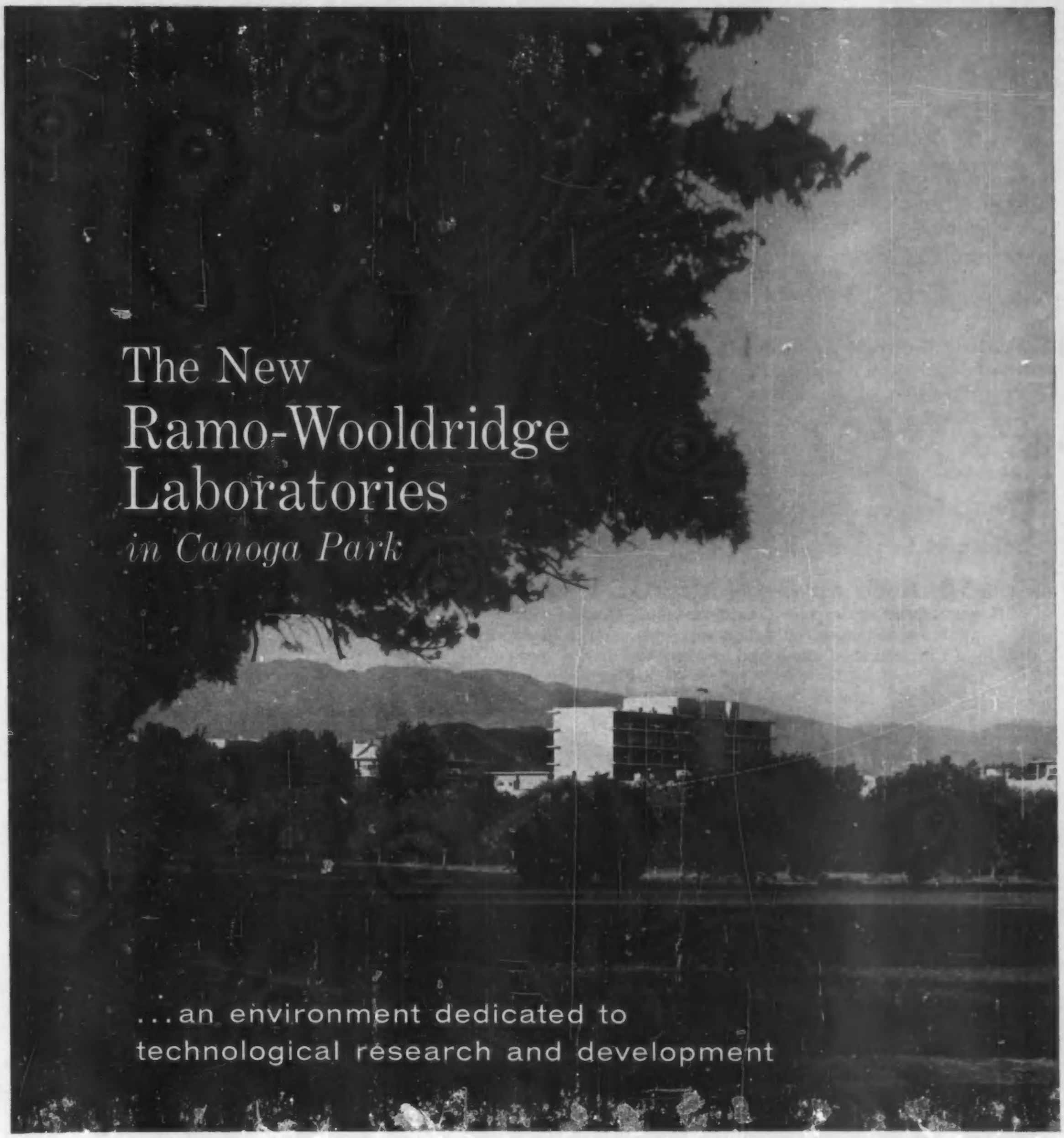
This small, lightweight servovalve amplifier, developed for proportional control of hydraulic transfer valves in missile and aircraft guidance systems, combines the low drift, reliability, and ruggedness of magnetic amplifiers with the space-saving compactness of semiconductor components. Unit provides a 8 madc push-pull output into two 1,400-ohm loads; control signal is 0.5 to 2.0 vdc into a 3,000-ohm load.—Vickers, Inc., St. Louis, Mo.

Circle No. 311 on reply card

PLUS . . .

(312) A new glass-base, epoxy-resin, **laminated plastic**, recently announced by **Taylor Fibre Co.**, Norristown, Pa., features high strength retention after high temperature exposure. . . . (313) **Technical Industries Corp.**, Pasadena, Calif., is now producing an **aluminum wire** with boron-free ceramic insulation capable of continuous service at 1,000 deg F.

Circle No. 312 or 313 on reply card



The new Ramo-Wooldridge Laboratories in Canoga Park, California, will provide an excellent environment for scientists and engineers engaged in technological research and development. Because of the high degree of scientific and engineering effort involved in Ramo-Wooldridge programs, technically trained people are assigned a more dominant role in the management of the organization than is customary.

The ninety-acre landscaped site, with modern buildings grouped around a central mall, contributes to the academic environment necessary for creative work. The new Laboratories will be the West Coast headquarters of Thompson Ramo Wooldridge Inc. as well as house the Ramo-Wooldridge division of TRW.

The Ramo-Wooldridge Laboratories are engaged in the broad fields of electronic systems technology, computers, and data processing. Outstanding opportunities exist for scientists and engineers.

For specific information on current openings write to Mr. D. L. Pyke.

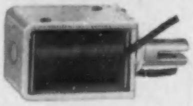
THE RAMO-WOOLDRIDGE LABORATORIES

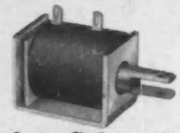
8433 FALLBROOK AVENUE, CANOGA PARK, CALIFORNIA

EVERYTHING UNDER CONTROL

with

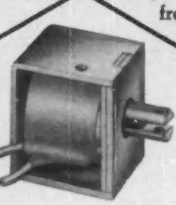
SOLENOIDS by GUARDIAN





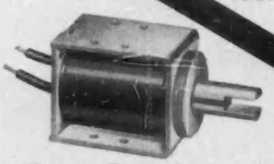
No. 22 D.C. Guardian's "mighty midget". Only 3/4" x 3/4" x 1 1/8" size. Stroke ranges from 1/32" to 5/16" and lifts up to 24 ounces. Available D.C. voltage only for intermittent or continuous duty.

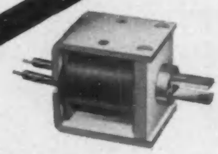
No. 24 A.C. Midget Solenoid. Only 1 1/4" x 1" x 7/8". Stroke ranges from 1/16" to 5/8" with lift over 19 ounces. Available for intermittent or continuous duty in any A.C. voltage up to 230 V.A.C.



No. 28 A.C. or D.C. MIDGET SOLENOID.

Announcement of this new Guardian midget solenoid will be greeted with eager interest by design engineers. It is most versatile. Has tapered plug and plunger for greater power. Adjustable stroke 1/16" to 1/2". Lift of over 41 ounces. Only 1 1/8" x 1" x 1 3/16". Available A.C. or D.C.; intermittent or continuous duty.



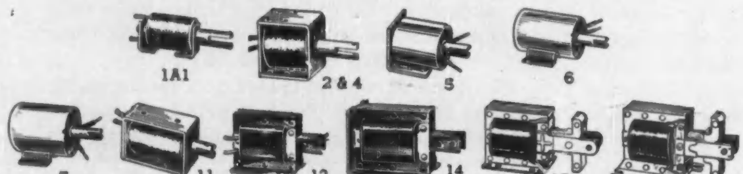


Heavy Duty No. 4 D.C. A version of Guardian's No. 4 solenoid. Has added power lift up to 9 pounds achieved by use of tapered plug and plunger, and special frame. Adjustable stroke 1/8" to 3/4". Available for continuous or intermittent duty with D.C. voltages up to 110 V. D.C.

Heavy Duty No. 2 A.C. or D.C. A new version of Guardian's well-known standard No. 2 solenoid having greater power and much longer life expectancy well in excess of 15 million operations. Adjustable stroke 1/32" to 3/4". Lifts more than 95 ounces. Available for A.C. or D.C.; intermittent or continuous duty.

Guardian offers the most complete, flexible and versatile line of solenoids ranging from midgets to heavy duty laminated types and for intermittent or continuous duty. Available with "Permaseal" encapulated coils and in D.C. units for 400 cycle operation.

LARGE SELECTIONS of Guardian Solenoids are carried in stock by Franchised Electronic Parts Distributors in the U. S. and Canada. Write for name of nearby distributor and Bulletin SD-25.



Write for Guardian Solenoid Bulletin SOL-8

GUARDIAN ELECTRIC
MANUFACTURING COMPANY
1623-P W. WALNUT STREET, CHICAGO 12, ILLINOIS

CIRCLE 162 ON READER SERVICE CARD

BULLETINS AND CATALOGS

NOTE: This month's Bulletins & Catalogs section starts with several items for which written requests are necessary. Complete addresses are given for these items.

RELAY TESTING. National Association of Relay Manufacturers, Attn: Professor Charles F. Cameron, P. O. Box 6, Stillwater, Okla. A 70-page progress report by NARM's Committee on Relay Testing Methods contains complete subcommittee reports on the following subjects: dry or low energy circuits; measurement of electrical characteristics; contact life testing; environmental testing including temperature, humidity, altitude, and corrosion; vibration testing; and shock, acceleration, and tumbling. Report presents suggested definitions and test procedures, discusses equipment and precautions, outlines work yet to be done, and solicits comments and suggestions on work already accomplished.

ROTARY COMPONENTS. Ketay Department, Norden Div., United Aircraft Corp., Commack, L. I., N. Y. This well indexed catalog contains 170 pages on the physical and electrical characteristics of Ketay's rotary controlled components. These include synchros, servomotors, resolvers, rate gyros, and potentiometers. Catalog also contains two pages on a line of hermetically sealed transistorized servo-amplifiers.

VARIABLE-SPEED DRIVE. Reeves Pulley Div., Reliance Electric & Engineering Co., Colombus, Ind. New 96-page catalog, designated M-592, uses hundreds of photographs, dimension drawings, and tables to illustrate the wide assortment of styles, modifications, and accessories available in the complete line of Reeves mechanical variable speed Motodrives. Tables list power ratings, output speed ranges, dimensions, and prices. Last eight pages provide useful engineering information on selection and sizes.

WIRE-WOUND POTS. Spectrol Electronics Corp., 1704 S. Bel Mar Ave., San Gabriel, Calif. About three-fourths of this 100-page Catalog 202 consists of specification sheets on a complete line of standard, wire-wound, single- and multi-turn precision potentiometers. Balance of the book describes Spectrol's facilities for designing and producing special tolerance potentiometers, special nonlinear potentiometers, and various types of precision mechanisms.

(350) PRECISION POTENTIOMETERS. Markite Corp. Design data and catalog, 48 pp. Sections cover characteristics of conductive plastic potentiometers, specifications of specific types, test procedures, applicable military specifications, and a glossary of potentiometer terms.

(351) STATISTICAL ANALYZER. GPS Instrument Co., Inc. Bulletin PDA-675F, 4 pp. Describes the company's probability distribution analyzer, an instrument developed to meet the need for analog simulation of noise in control systems.

(352) PACKAGED CONTROL. Airborne Accessories Corp. Bulletin, 4 pp. Contains charts, characteristics tables, and

photos or a new compact control system for airborne applications.

(353) COMPLETE ACTUATOR LINE. The Annin Co. Bulletin 1236ST, 18 pp. Well executed, four-color, sectional drawings illustrate a complete line of pneumatic, electropneumatic, electrohydraulic, and pneumatic-hydraulic valve actuators for fluid flow control systems.

(354) REPLACEMENT CHART. Bendix Aviation Corp. Chart, 2 pp. Lists about 300 transistor types along with suggested Bendix replacements. Also indicated are types not packaged according to EIA standards and Bendix models with lug-type leads.

(355) PHOTOELECTRIC CONTROLS. Cramer Controls Corp. Bulletin IB-1-959, 4 pp. Covers design, operation application, and characteristics of a precision photoelectric control system which operates on infrared radiation.

(356) CODED BAR SWITCHES. Computer Control Co., Inc. Bulletin CBS 1, 4 pp. Photographs and a cutaway drawing illustrate the mechanical design of new keyboard switches featuring direct binary-coded outputs.

(357) TEST INSTRUMENTS. Minneapolis-Honeywell Regulator Co. Catalog G-10, 48 pp. Briefly describes a wide variety of instruments for scientific measurement, recording, and control applications. Follows each list of general specifications with a reference to a more detailed bulletin.

(358) COMPLETE RECORDER LINE. General Electric Co. Bulletin GEA-6933, 12 pp. Designed to simplify selection of General Electric recorders, bulletin has divided instruments according to their accuracy class. Covers applications, operating specifications, and special features of various types in each class.

(359) GAS ANALYSIS CONTROL. Bailey Meter Co. Performance report QG10.3-1, 4 pp. Tells how a Bailey oxygen analyzer was used to control excess air in a glass furnace at a Pennsylvania Glass Co. Series of four chart records shows progression from full manual to full automatic control.

(360) AUTOMATIC WEIGHING. Weighing & Control Components, Inc. Catalog 14, 24 pp. Explains the application of the company's standardized instrumentation system to batch or continuous weighing of bulk materials.

(361) TELEMETERING SYSTEM. Telemetering Corp. Bulletin, 4 pp. Describes the Model TU-1A transistorized telemetering system, a compact portable package for a wide variety of field applications. Photos illustrate its encapsulated transmitter and FM receiver, both powered by mercury batteries.

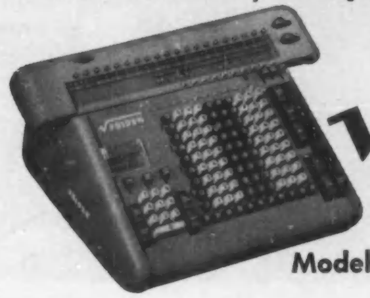
(362) VENTILATOR CONTROLS. Barber-Colman Co. Application Manual, 86 pp. Offers detailed descriptions of the company's automatic control systems for hot water, steam, gas-fired, and electric unit ventilators. Actual control applications are shown on each page, covering all makes and models marketed by the major unit ventilator manufacturers.

(363) SOLID-STATE TESTER. Stromberg-Carlson Div. of General Dynamics Corp. Bulletin 307, 24 pp. Well illustrated booklet covers the design and opera-

FRIDEN MODEL SRW...

"in no time"

does a problem that once was tedious, complex



SQUARE ROOT ...appears automatically in the dials of Friden Model SRW when you touch one key

SEE HERE HOW IT'S DONE

1 Set number from which root is to be taken on Friden SRW keyboard

2 Touch Square Root key corresponding to position of decimal point in the radicand

3 See root appear in dials. This figure can be retained on keyboard if desired for further calculation. Need for copying root is eliminated

For the first time on any desk calculator Friden Model SRW provides touch-one-key extraction of square root. This of course is in addition to all standard Friden Calculator features. Thus Friden Model SRW is The Thinking Machine of American Business *PLUS.* It performs more steps in figure-work *without operator decisions* than any other calculating machine. Can you use one?

Friden ...WORKS THE WORLD'S FIGURE-THINKING PROBLEMS AUTOMATICALLY

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CIRCLE 163 ON READER SERVICE CARD


Nuclear Rocket Controls

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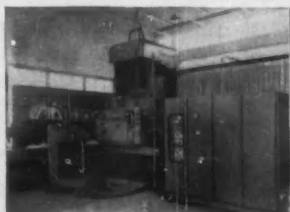
Opportunities exist at Bendix Research Laboratories for stimulating work in the following areas: Fluid Power Servo and Dynamic Analysis • Hydraulic and Pneumatic Servo Controls • Thermodynamics and Heat Transfer • Hot Gas Devices • Material, Lubrication, Wear and Friction.

You will find this work unusually stimulating and satisfying. Comfortable and pleasant surroundings in suburban Detroit, with opportunity for advanced study at nearby universities.


Tape Controlled Milling Machine


Hydraulic Servo Motors

If interested, please write or call (collect) Fred A. Barry, Research Laboratories Division, Bendix Aviation Corporation P. O. Box 5115, Detroit 35, Michigan. Phone: KEnwood 7-3300

Research Laboratories Division
SOUTHFIELD, MICHIGAN

Bendix
AVIATION CORPORATION

Bulletins & Catalogs

tion of SCATE, a preprogrammed automatic test system using solid-state devices in computer circuit modules. Photographs and block diagrams illustrate discussions of its various units.

(364) DIGITAL VOLTMETERS. Non-Linear Systems, Inc. Bulletin 8159/20M, 20 pp. Covers a line of digital voltmeters for ac and dc measurements and includes a 2-page explanation of the instrument's transistorized "no-needless-nines" logic. Gives complete specifications, operating information, and a 3-page picture section for input and output accessories.

(365) ACCELEROMETERS. Endevco Corp. Brochure, 20 pp. Combines the advantages of an instruction manual with thorough coverage of the state of the art in dynamic accelerometer methods and equipment. Sections include application information, discussion of piezoelectric materials, nonvibration environments, shock measurements, calibration techniques, and several others.

(366) DESK-TOP COMPUTER. Electronic Associates, Inc. Bulletin AC934, 10 pp. Presents the PACE TR-10 transistorized desk top analog computer with detailed component specifications and descriptions. Illustrates the computer program and plotted solution to a typical engineering problem.

(367) ELECTRIC FLOWMETER. Thermal Instrument Co. Bulletin 800, 2 pp. Describes a low flow electric flowmeter that uses the thermal conductivity bridge principle. Illustrations include photographs, a schematic of the flow measurement system, and a calibration curve.

(368) SMALL BASIC SWITCHES. Micro Switch Div. of Minneapolis-Honeywell Regulator Co. Catalog 63, 20 pp. Covers four important switch groups and amplifies each section with data on the various types of actuators available. Dimension drawings accompany most of the switch descriptions.

(369) POWER CONNECTORS. DeJur-Amsco Corp. Catalog form 1416-659, 20 pp. Introduces a group of miniature power connectors for heavy duty applications in guided missiles, aircraft, and electronic equipment. Actual size photographs accompany each description.

(370) PULSE TRANSFORMER DATA. Technitrol Engineering Co. Bulletin PT-204, 205, and 206, 4 pages each. Published to aid in the design of low power pulse transformer circuits, these bulletins cover blocking oscillator applications, interstage coupling applications, and specific applications where transformer parameters are known. Each brochure discusses the characteristics of the pulse transformer which distinguish it from other circuit elements and lists applications of the pulse transformer as a coupler and wave shaper.

(371) TIME DELAY RELAYS. Tempo-Instrument, Inc. Bulletin 5903, 8 pp. Offers complete technical data on the company's line of electronic time delay relays and contains a comprehensive description of circuit design, manufacturing and assembly processes, standard and special specifications, and other detailed data.

(Continued from page 52)

fortunately, even faster than it started up as set designers improved circuitry to allow built-in antennas and shifted into portable and movable models. As the home TV antenna market started to disappear (TACO still makes 1,000 units a day, mostly for replacement markets or for sale in fringe reception areas), TACO looked around for a new outlet for the company's energies, espied the closely related military and industrial antenna field. Today the company's growth is geared to this market.

As recently as 1958, home TV antenna sales made up 60 percent of TACO's \$1.5 million annual sales. But in the first six months of 1959, military and industrial sales had mushroomed to 70 percent of the company's six-month total sales of \$2½ million. Now TACO president, H. H. Brown, predicts the company's sales will quadruple in the next year—with all the growth in the military and industrial antenna business.

To accelerate the growth, the company last month dedicated a \$50,000 antenna test range in New York State's apple-growing Chenango County. Situated on two interference-free hilltops, 3,000 feet apart, the test facility will conduct R&D work on new designs and test production models.

One place the company plans to increase its participation is in missile and space vehicle tracking.

The way TACO's growth will come about is through new products such as the new high gain, trihelical antenna for telemetry work, just announced. TACO will offer this unit in a variety of sizes—4-, 6- ,8-, and 10-turn models and with a broad choice of mounts including an automatic azimuth and elevation orientation system.

In the industrial field TACO has been eying supervisory control, has noted a recent increase in popularity of microwave systems. The company will offer a line of antennas designed to serve utility and pipeline companies which are sending supervisory control and data signals by microwave.

Topp, United Industrial Form \$32 Million Company

United Industrial Corp. and Topp Industries Corp. will merge to form a new UIC with \$27 million assets and estimated annual sales volume of \$32 million. The purpose: to allow diversi-

New! REAR-PROJECTION-TYPE

IN-LINE DIGITAL DISPLAY

FEATURES
ONE-PLANE PRESENTATION

Series 80,000
In-Line Display

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DESIGNED FOR FAST EASY READING OF
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- Display boards
- Test equipment
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Price Per Unit
\$33.00

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North Hollywood, California

CIRCLE 199 ON READER SERVICE CARD

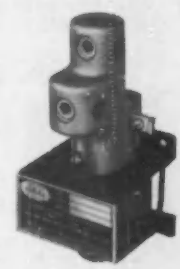
A lot at stake?

depend on

A+ Adlake

mercury to mercury relays

Wherever foolproof performance is important, depend on relays that can't burn, pit or stick. Depend on mercury-to-mercury contacts of Adlake, rated A+ for design and construction. The Adams & Westlake Company, Elkhart, Indiana. Original and Largest Manufacturer of Plunger-type Relays.



Illustrated — heavy duty 1101 —87T type with compression terminals.

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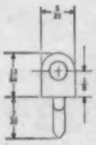
CHECK THE LOW COST of these new printed circuit test jacks

Patents pending



For .052 application holes on .400 centers

Samples on request

Ucinite's new test jack is designed for permanent, soldered assembly to printed circuit boards. Gold-over-silver-plated beryllium copper contacts provide low-resistance contact for repeated insertions of standard .080" diameter test probes. Nylon bodies are available in eleven standard code colors. Uniquely simplified construction affords economical usage in all quantities. Immediate shipments from stock.

ELECTRICAL DOT ASSEMBLIES

The UCINITE COMPANY
Division of UNITED-CARR Fastener Corporation
Newtonville 60, Massachusetts

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DIGITAL TRANSDUCER

provides mechanical encoding for read-out and logging systems

The new Series 400 Digital Transducer utilizes a standard sensing element (flow, pressure, or temperature) to actuate the mechanical American Force Amplifier which precisely positions a shaft encoder. The need for electronic accessories is eliminated. Increased reliability and simpler maintenance are assured.

SPECIFICATIONS

Accuracy: 1% of span.
Repeatibility: 0.5% of span.

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fication of product lines, along with the usual aims of coordinating complementary facilities, personnel, and recourses.

United manufactures material handling equipment and other heavy machinery. Aircraft Armaments, Inc. (80 percent UIC-owned) makes controls, computers, and testing equipment along with other defense goods. Hayes Aircraft Corp. (30 percent UIC-owned) modifies aircraft and makes missile instrumentation. Topp produces electronic and electromechanical devices and systems. It has three subsidiaries in the control field, U.S. Science Corp., Micro-Path, Inc., and U.S. Semiconductor Products.

Other Acquisitions

AG Chemisches Institut Dr. A. G. Epprecht—by **Contraves AG,** both of Zurich, Switzerland. The new acquisition specializes in precision fluid and solid flow measuring equipment, viscosity instruments, rheometers, and electronic tensile stength measuring instruments. Contraves AG is a leading Swiss control firm.

Magnaflux Corp.—by **General Mills, Inc.,** Minneapolis, Minn. The Chicago firm is a pioneer developer of techniques and equipment for nondestructive testing.

IMPORTANT MOVES BY KEY PEOPLE

Republic Adds Dr. Lubkin To Advise on Computers

Dr. Samuel Lubkin has become a staff consultant to the Missile Systems Div. of Republic Aviation Corp. in Farmingdale, N. Y. Dr. Lubkin, digital computer specialist, has held top level positions in the computer operations of several industrial firms and the government. Before joining Republic he was manager of digital computer developments for the Electronics Div. of Curtiss-Wright Corp. and before that was director of the Electronic Computer Div. of Underwood.

Kindle New Chief Engineer At Electronic Associates

A new post at Electronic Associates, Inc., chief engineer, will be filled by William K. Kindle, who has been with EAI for three years. The job had been eliminated several months ago, when Fred L. Martinson was elevated from it to be vice-president, engineer-

New

TRANSISTORIZED D-855 GAUSSMETER

- Complete portability for use in field or lab
- Reads flux fields up to 30,000 gauss
- Can be equipped to read Earth's field flux density
- Probe is only .025" thick
- Active area of probe .01 square inches
- Fully transistorized
- Power Supply: selective from 105-125 volt 50-60 cycle line or internal batteries
- Net weight: 8-3/4 lbs.
- Overall size: 13-1/2" high, 8-3/4" wide, 7-1/4" deep

Precision built, completely transistorized, the new D-855 Gaussmeter accurately measures flux density and determines "flow" direction. Ideal for measuring and locating "stray fields", plotting variations in strength and checking production lots against a standard. It's simple to operate. The Dyna D-855 doesn't require jerk or pull, gives no ballistic reading. Can be operated in the field with batteries which are enclosed in rugged protective carry case. This is an improved version of the pioneering D-79 Gaussmeter (Pat. #2,707,769) which has modernized magnetic flux measurement for the past six (6) years.

DYNA-EMPIRE, Inc.
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Pioneer 1-2700

CIRCLE 201 ON READER SERVICE CARD

ing as a step toward creating an Engineering Div. Continued expansion has made felt the need for another level of engineering authority.

Kindle, who will report to Martinson, will be responsible for evaluation and improvement of the Long Branch, N. J., company's products, development of new products, and technical service to customers.

Blakely To Head Product Planning at Univac

As chief engineer of product planning at Remington Rand Univac Div., Sperry Rand Corp., Robert T. Blakely will be in charge of technical evaluation of new product planning programs and the development of new product specifications. He'll also supervise the product planning representatives in regional offices and planning department in Univac's plants.

Before joining Rem Rand, Blakely was corporate staff engineer at Burroughs Corp. He also was a manager at Burroughs' Research Center. Previously, Blakely held manager's positions at IBM plants in Kingston and Poughkeepsie, N. Y.

(Continued on p. 168)

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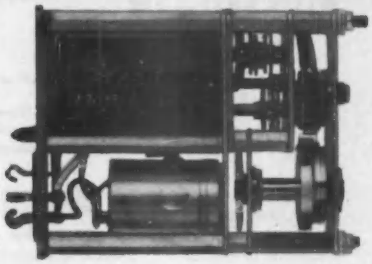

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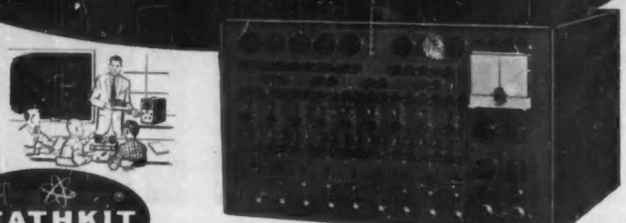
NEW! An Electronic ANALOG COMPUTER KIT for just $199.95



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SPECIFICATIONS: Amplifiers: 9 D.C. Operational Amplifiers using one 6U8 per amplifier; each solves mathematical problems; each balanced by individual panel control without removing problem set-up. Computing components mount on connectors and plug into panel sockets. Open loop gain approximately 1000. Output −60 to +60 volts at 3 ma. **Power Supplies:** +300 volts at 25 ma electronically regulated; variable from +250 to +350 by control with meter reference for setting +300 volts. Negative 150 volts at 40 ma regulated by VR tube. **Coefficient Potentiometers:** Five on panel. **Initial Condition Potentiometers:** Three on panel; used to introduce initial velocity, acceleration, etc. on the three "given" quantities. **Repetitive Operation:** Multivibrator cycles a relay at adjustable rates (.1 to 15 CPS), to repeat the solution any number of times; permits observation of effect on solution of changing parameters. **Meter:** 50-0-50 ua movement. **Power Requirements:** 105-125 volts, 50-60 cycles, 100 watts. **Dimensions:** 19¾" W. x 11⅛" H. x 15" D.

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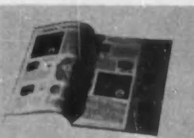

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First Czech Nobel Winner Is Polarography Inventor

New Nobel chemistry laureate, Dr. Jaroslav Heyrovsky, inspects his model LP-55 polarograph in the lab at the Czechoslovak Academy.

VIENNA—

For his 1922 invention of the polarograph, Dr. Jaroslav Heyrovsky, 69-year old head of the Polarography Institute of the Czechoslovak Academy of Sciences, has won the 1959 Nobel Prize for Chemistry and its accompanying $42,606 cash award; he is the first Czech Nobel laureate. Polarography, now the world's fifth most used analytical method, identifies and determines the concentrations of substances in solution based on their voltage-current relationships in an electrolytic cell.

Dr. Heyrovsky developed the falling drop of mercury electrode, which is the heart of the polarograph, in the course of an informal talk with his professor following his doctorate examination in 1918. Since then almost his entire career has been devoted to the development of polarography.

The professor worked through World War II in occupied Czechoslovakia and wrote a text on polarography that was published in Vienna in 1941. Also during the occupation he started the development of oscillographic polarography and carried on work in inorganic chemistry.

Post war lecture tours took Dr. Heyrovsky to Great Britain, Austria, Hungary, Poland, Bulgaria, East Germany, and Red China. In 1933 a Carnegie Visiting Professorship had brought him to the U. S. where he lectured at six universities.

The falling drop of mercury electrode for the cell results in the method yielding highly reproducible results. It is also rapid, very sensitive, and accurate (½ to 5 percent error even at concentrations as low as 10^{-6}M. The

(Continued on p. 171)

IMPORTANT: Circle key numbers below and mail before March 1, 1960

	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190
1	11	21	31	41	51	61	71	81	91	101	111	121	131	141	151	161	171	181	191
2	12	22	32	42	52	62	72	82	92	102	112	122	132	142	152	162	172	182	192
3	13	23	33	43	53	63	73	83	93	103	113	123	133	143	153	163	173	183	193
4	14	24	34	44	54	64	74	84	94	104	114	124	134	144	154	164	174	184	194
5	15	25	35	45	55	65	75	85	95	105	115	125	135	145	155	165	175	185	195
6	16	26	36	46	56	66	76	86	96	106	116	126	136	146	156	166	176	186	196
7	17	27	37	47	57	67	77	87	97	107	117	127	137	147	157	167	177	187	197
8	18	28	38	48	58	68	78	88	98	108	118	128	138	148	158	168	178	188	198
9	19	29	39	49	59	69	79	89	99	109	119	129	139	149	159	169	179	189	199

200	210	220	230	240	250	260	270	280	290	300	310	320	330	340	350	360	370	380	390
201	211	221	231	241	251	261	271	281	291	301	311	321	331	341	351	361	371	381	391
202	212	222	232	242	252	262	272	282	292	302	312	322	332	342	352	362	372	382	392
203	213	223	233	243	253	263	273	283	293	303	313	323	333	343	353	363	373	383	393
204	214	224	234	244	254	264	274	284	294	304	314	324	334	344	354	364	374	384	394
205	215	225	235	245	255	265	275	285	295	305	315	325	335	345	355	365	375	385	395
206	216	226	236	246	256	266	276	286	296	306	316	326	336	346	356	366	376	386	396
207	217	227	237	247	257	267	277	287	297	307	317	327	337	347	357	367	377	387	397
208	218	228	238	248	258	268	278	288	298	308	318	328	338	348	358	368	378	388	398
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2	12	22	32	42	52	62	72	82	92	102	112	122	132	142	152	162	172	182	192
3	13	23	33	43	53	63	73	83	93	103	113	123	133	143	153	163	173	183	193
4	14	24	34	44	54	64	74	84	94	104	114	124	134	144	154	164	174	184	194
5	15	25	35	45	55	65	75	85	95	105	115	125	135	145	155	165	175	185	195
6	16	26	36	46	56	66	76	86	96	106	116	126	136	146	156	166	176	186	196
7	17	27	37	47	57	67	77	87	97	107	117	127	137	147	157	167	177	187	197
8	18	28	38	48	58	68	78	88	98	108	118	128	138	148	158	168	178	188	198
9	19	29	39	49	59	69	79	89	99	109	119	129	139	149	159	169	179	189	199

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202	212	222	232	242	252	262	272	282	292	302	312	322	332	342	352	362	372	382	392
203	213	223	233	243	253	263	273	283	293	303	313	323	333	343	353	363	373	383	393
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205	215	225	235	245	255	265	275	285	295	305	315	325	335	345	355	365	375	385	395
206	216	226	236	246	256	266	276	286	296	306	316	326	336	346	356	366	376	386	396
207	217	227	237	247	257	267	277	287	297	307	317	327	337	347	357	367	377	387	397
208	218	228	238	248	258	268	278	288	298	308	318	328	338	348	358	368	378	388	398
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(Continued from p. 168)
majority of elements and a variety of organic substances may be determined using polarographic equipment; it has wide applications in the chemical industry, metallurgy, food production, pharmacy, biology, and medicine (cancer diagnosis, for instance). Latest applications are in continuous recording for on-line process control.

Though he devised the method in 1922, Dr. Heyrovsky didn't build the first automatic polarograph until 1925, at Charles University, Prague, with Masuzo Shikata. Today 60 or more types are being produced in 15 countries. E. H. Sargent & Co., Chicago, owns the term "polarograph" and is the largest manufacturer. The principle of the device remains the same; improvements have involved versatility (self-contained and portable units) and ruggedization (galvanometers replaced by pen-recorders).

Asked what he'll do with the $42,606 prize, Dr. Heyrovsky told CtE "All my research and all costs of Polarographic Institute are financed by the State. For philanthropic purposes I cannot use it, because in Czechoslovakia, social welfare is also cared for by the State. I shall have to find out what to use it for."

—Fred Baer
McGraw-Hill World News

Other Important Moves

George E. Bartlett will have administrative responsibility for the engineering activities of the E. Aurora, N. Y., plant of Moog Servocontrols, Inc. as new engineering manager.

Boyd Dahle, the new chief engineer of Sierra-Schroeder Div. of Idaho Maryland Mines Corp., had held the same position at the Air-Gas Valve Div. of Parker Aircraft Co. He'll further the development of the Glendale, Calif., company's products.

Dr. Leonard Pode has joined General Controls Co. to be chief engineer of its Electronic Systems Div. He was with the Norair Div. of Northrop Corp. before coming to the Los Angeles, Calif., firm.

Robert E. Talmo and **Peter H. Escher** have new positions at Electro-Optical Systems, Inc. Talmo joins EOS to head a new Transducer Lab. in the Solid-State Div., coming from Wiancko Engineering Co. Escher precedes Talmo by six months and has now became manager of Electronics Systems Div. in Pasadena, Calif.

What can you do with a remarkable instrument like this?

We knew we had an outstanding instrument in our product line when this readout device was introduced several years ago. It proved to be ahead of its time during those early days, but now this remarkable precision instrument for displaying data is gaining acceptance in many industries. It's about as big as a candy bar, and it will display, store, or transfer up to 64 different numbers, letters, or symbols without using complicated conversion equipment and "black boxes."

This is an entirely new species of readout device so we had to give it a new name, the Readall* readout instrument.

We developed the Readall instrument for data display in flight control equipment. We knew the Readall instrument was fine but didn't know just *how* valuable it was. But one of our engineers did. He designed a complete new pipeline control system based on the new instrument. The application was a breakthrough in data handling, and the control system is a big success.

Naturally, we put the Readall instrument on the market so systems engineers could use it to improve their control systems. We announced the Readall instrument as ". . . an electro-mechanical, D.C. operated, readout device for displaying characters in accordance with a pre-determined binary code . . . a compact, self-contained device . . . which can be applied to the output of digital computers, teletype receiving equipment, telemetering systems, or wherever data must be displayed."

Other systems have been developed with separate units for data display, decoding, storing, and electrical readout. These separate units cost more and occupy more room. Market response confirms the need for *one, small,* inexpensive unit that does all three jobs. The Readall instrument serves the purpose.

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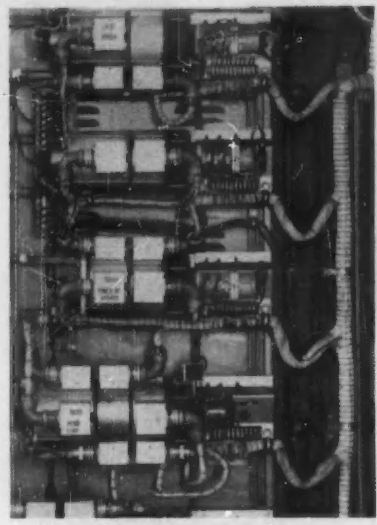

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ABSTRACTS

3½-Hour sine waves

From "A Sine-Wave Generator with Periods of Hours", by G. Klein and J. M. Den Hertog, Philips Research Laboratory, Eindhoven, Netherlands. Article in "Electrical Engineering" (London), June 1959, pp. 320-325.

Lowering the frequency of sinusoidal voltages generated by the usual phaseshift oscillators (RC or Wien bridge types) is limited from a practical point of view because switching on or changing the frequency setting of such oscillators causes a transient distortion that requires 5 to 10 cycles to die out. Such distortion can thus make the equipment unuseable for long periods after a change. Sinusoidal voltages therefore have been made by distorting triangular voltages by means of diodes or other nonlinear elements. By using good capacitors, triangular voltages of comparatively long periods can be made easily.

The principle of the new ultra low frequency generator can be seen from Figure 1. Because of the negative feedback to point 2, point 3 is forced to follow a triangular voltage on point 4. If this triangular voltage has the correct amplitude a sinusoidal voltage with the amplitude of the high frequency sinewave on 1 and the frequency of the trinagular voltage will be present at point 2. Correct adjustment of the amplitude of the triangular voltage on 4 is ensured by the fact that the voltage on 3 determines the point of reversal.

The principal part of the inverse function generator (Figure 2) is a difference amplifier. A difference amplifier only amplifies the potential difference between the input terminals 1 and 2 and not the voltage difference which these points have in common with respect to ground. By increasing the amplification to a very high level and keeping the output voltage between an upper limit V_H and a lower limit V_L by means of a limiter, the following very close approximation applies:

$$V_{out} = V_H \text{ for } V_{12} \text{ positive}$$

$$V_{out} = V_L \text{ for } V_{12} \text{ negative}$$

If a relatively high-frequency sine wave is applied to input 1 of the inverse function generator as connected in Figure 1, and a very low frequency sine wave to input 2, the output will be a triangular wave with the period of the applied low frequency. In the system of Figure 1, the low frequency applied is actually the output of the generator. The high frequency source is an auxiliary oscillator which is limited to the amplitude of the low frequency signal. The auxiliary oscillator need not be very stable as regards frequency, since this affects neither the frequency nor the amplitude of the low frequency output.

The signal generator based on these principles yields sinusoidal (and triangular) voltages with periods from 20 to 12,500 sec in 20 steps. An amplitude of 50 volts peak to peak with a distortion of less than 1 percent results when regulated power supplies are used. Complete circuit details and theory are given in the article.

Fig.1

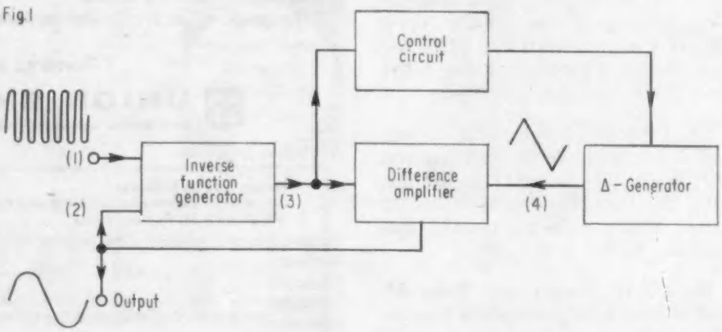
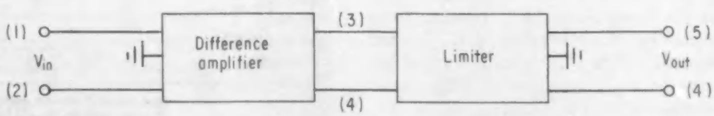


Fig. 2



Instrumentation problems: management viewpoint

From "Personnel Needs for Tomorrow's Instrumentation As Seen by Today's Management" by C. L. Parish, Monsanto Chemical Co. Paper presented at the 14th annual Instrumentation-Automation Conference of the Instrument Society of America, Chicago, Ill., September 21-25, 1959.

Today's management sees many personnel needs for tomorrow's instrumentation. Today's management in the process industries is not "for instrumentation". Rather, management wants to use as little of it as it can. But management, viewing instrumentation as a means to the end of greater profits for less business effort, believes that instrumentation can be applied properly to chemical processes to make great savings. New and better instrumentation will be required and will be developed. Management suspects that this instrumentation will be more complex, and will account for a greater percentage of its physical plant. Lest our ability to capitalize on these developments be limited by our ability to install and service them, we need to start analyzing our personnel needs now for the coming years, and to start now, ourselves, to provide for these needs. The needs are many, including numbers of people, their proper organization and employment and the way in which they will carry out their jobs, their job classifications, their union relationships, and their training and education. But the greatest need is in the field of training and education. Because our problem is somewhat special within our industry rather than of general application, it is imperative that we ourselves take the initiative in educating for tomorrow.

Briefly noted

From "Some Problems Associated With The Measurement of Very Low Pressures", by George J. Maslach, 1958, 30 pp. AGARD Report 175, North Atlantic Treaty Organization, Advisory Group for Aeronautical Research and Development.

Describes the several types of pressure sensitive elements now used for the measurement of very low pressures and presents a method of design for the connecting line joining an orifice to a pressure sensitive element. Shows that the time response is affected by out-gassing effects and variable temperatures and indicates corrections. Measurements illustrate external flow effects at low densities.

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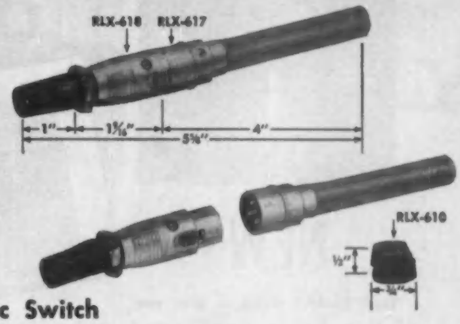

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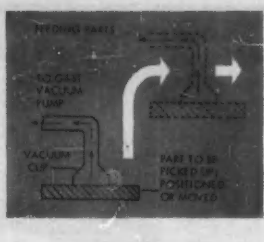


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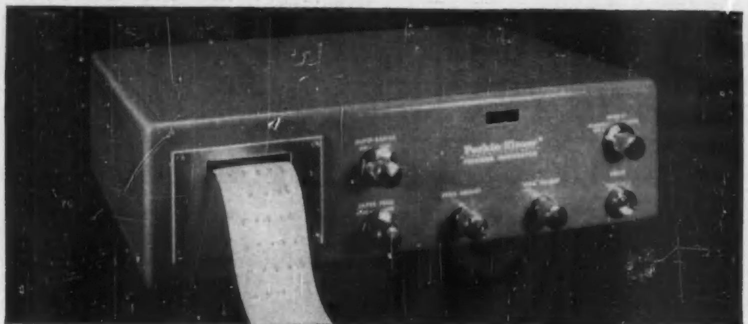

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Actuator Text

ELECTRIC ENERGY CONVERSION. Y. H. Ku, *University of Pennsylvania.* 522 pp. *Published by The Ronald Press Co., New York.* $10.

Departing greatly from "standard" scholarly treatises that deal with electrical machines, the author attempts to coordinate the different branches of an extremely broad subject by presenting a highly mathematical, unified treatment of energy conversion. Written primarily to serve in an introductory course in electrical machinery for junior and senior students in electrical engineering, all but three short chapters are devoted to alternating current types of equipment. Discussions of the latter, making up the bulk of the text—some 350 pages—include transformers, synchronous and induction machines, and servo and capacitor motors. Other topics treated briefly are direct current machines, self-synchronous systems, metadynes, and control systems that incorporate rotating amplifiers.

Although the mathematical aspect of the subject is authoritative, rigorous and well presented, equations have, for the most part, obscured the physical realities of such fascinating equipment as transformers and rotating machines. Since the discussions in the form of word pictures are generally sketchy, this reviewer feels that undergraduate students unfamiliar with electrical equipment would find it difficult to relate mathematical concepts to meaningful energy converters; moreover, not a single drawing or photograph is included.

Considerable stress is placed upon the study of the steady state and transient characteristics of synchronous machines, Chapters 5 to 10. The presentation of the material is generally good and is further augmented by the solution of several fine examples.

It is particularly regrettable that the author felt it necessary to devote a disproportionately large part of a text about the general theory of energy converters to the subject of synchronous machines. This misplaced emphasis is obviously the reason for the meager treatment of such extremely important topics as static and transient analyses of direct current machines, the several types of polyphase and single-phase induction motors, frequency and phase converters, control systems, and others. However, it should be pointed out in this respect that graduate students and practicing

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NEW BOOKS

engineers will find the chapters on synchronous machines excellent source material; this may, indeed, be the book's worthy objective.

A fine bibliography, given at the end of each chapter, should be especially useful to those doing advanced work; they do not, in the main, appear to be suitable as references for undergraduate students.

C. S. Siskind
Purdue University

Full of Meanings

CONCISE DICTIONARY OF SCIENCE. *Frank Gaynor, 546 pp. Published by Philosophical Library, Inc., 15 E. 40th St., New York 16, N. Y.* $10.

This book contains brief definitions of over 7500 technical words and expressions drawn from various branches of the physical-sciences.

Drawing Guide

FLUID POWER DIAGRAMS. *Section 17 of the American Drafting Standards Manual. 24 pp. Published by American Society of Mechanical Engineers, 29 W. 39th St., New York 18, N. Y.* $1.50.

This publication, designated American Standard Y14.17-1959, is one of 18 sections of the American Drafting Standards Manual which, when completed, will provide the means for obtaining uniform drafting practices throughout the United States. Sections 1 through 7 and 9, 10, and 11 have been published. Sections 8, 12 through 16, and 18 are still in preparation.

Section 17 establishes standard drawing practices for depicting systems that use a fluid within enclosed circuits to transmit and control power. Drawings of hydraulic or pneumatic circuits for control or transmission of power differ in many ways from most other engineering drawings, since extensive explanatory notes and data are usually required. Therefore, this publication explains in detail the data and notes that should accompany symbols and lines to make a diagram meet the requirements of engineering, sales, purchasing, and maintenance. Four types of diagrams are covered by the standard: pictorial diagrams, which show only external features of components; cutaway diagrams, which show principal internal working parts;

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graphical diagrams, which provide a simplified method of showing function and method of operation of each component; and combination diagrams, which combine the previous three to emphasize, for each part, the function that best suits the purpose of the diagram. Standard symbols for each type of diagram are illustrated. These symbols include components; piping; and capacity, power, and other ratings. Standard drafting practice is used for such things as line conventions, lettering, sheet size, and title block.

Important Revision

TEXTBOOK OF PHYSICS. R. Kronig, 961 pp. *Published by* Pergamon Press, Inc., New York 22, N. Y. $15.

This second edition of a comprehensive textbook on physics is greatly expanded and brought up to date. It will have particular interest for those who, while not actually working as physicists, require knowledge of this field from time to time; included in this group are design engineers, biologists, chemists, etc. To meet the requirements of these various categories, smaller type is used to cover the more advanced passages and asterisks set off topics of more specialized interest in such a manner that those who wish to omit this more detailed data may do so without destroying continuity of the subject under study.

Four major divisions constitute the organization of the material. The first deals with vibrations, electrodynamics, mechanics, and optics. The second covers atomic theory including interpretation of the properties of matter in atomic terms. The third consists of two chapters devoted to physicial instruments and the book ends with a survey of medical physics. Data on new experimental techniques, such as the bubble chamber and microwave spectroscopy, is included.

Another improvement over the first edition is the addition of test problems at the end of each chapter. In conformance with the author's desire to arrange the material to suit various categories of readers, the problems are grouped into three sections, classified according to difficulty. Some readers may find of particular interest and use the fact that throughout the book, the rationalized Giorgi system based on four fundamental units is employed.

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DECEMBER

Fourth Midwest Symposium on Circuit Theory, sponsored by IRE Professional Group on Circuit Theory, Brooks Memorial Union, Marquette University, Milwaukee, Wisc. Dec. 1-2

Eastern Joint Computer Conference, sponsored by AIEE, ACM, and IRE, Hotel Statler, Boston, Mass. Dec. 1-3

American Institute of Chemical Engineers, Annual Meeting, Sheraton Palace Hotel, San Francisco, Calif. Dec. 6-10

JANUARY

Sixth National Symposium on Reliability and Quality Control, sponsored by IRE, AIEE, ASQC, and EIA, Statler Hilton Hotel, Washington, D. C. Jan. 11-13

Case Institute of Technology, Operations Research Short Course, Campus, Cleveland, Ohio Jan. 18-29

Stress Measurement Methods Symposium, sponsored by *Strain Gage Readings* (journal), Arizona State University, Temple, Ariz. Jan. 25-29

American Institute of Electrical Engineers, Winter General Meeting, New York City Jan. 31-Feb. 5

FEBRUARY

Instrument Society of America, Instrument-Automation Conference and Exhibit, Houston Coliseum, Houston, Tex. Feb. 1-5

Institute of Radio Engineers, Winter Convention on Military Electronics, Ambassador Hotel, Los Angeles, Calif. Feb. 3-5

Seventh Annual Solid-State Circuits Conference, sponsored by IRE, AIEE, University of Pennsylvania, Philadelphia, Pa. Feb. 10-12

MARCH

Instrument Society of America, Temperature Measurement Symposium, Deshler Hilton Hotel, Columbus, Ohio March 9-11

Institute of Radio Engineers, National Convention, Coliseum and Waldorf-Astoria Hotel, New York City March 21-24

22nd Annual American Power Conference, sponsored by Illinois Institute of Technology, Hotel Sherman, Chicago, Ill. March 29-31

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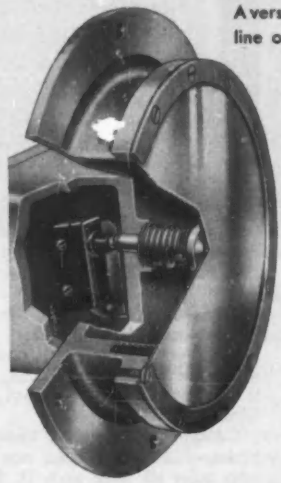

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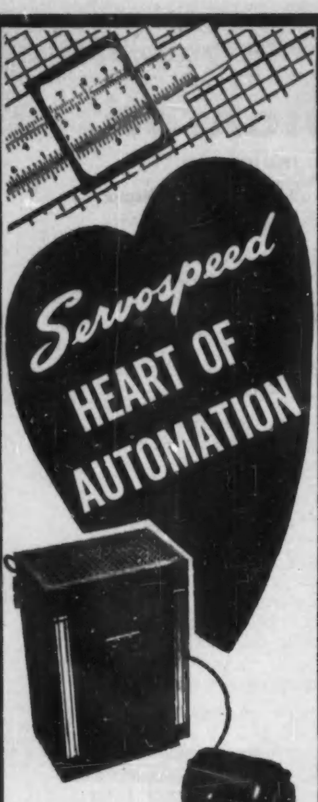

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Continued on page 180

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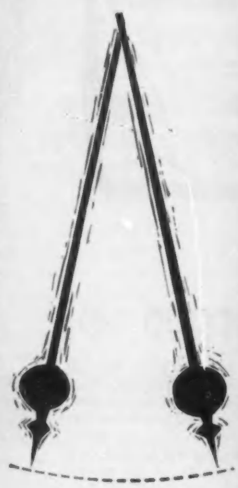

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How The Plan Works

There are, however, some well-tested ways of providing aid which improve rather than fade in appeal with more using. One such way is the making of supplemental tuition payments to colleges and universities at which a company's employees take courses.

Many companies have scholarship or tuition-refund programs which cover all or part of the costs to their *employees* of taking college courses. But, in most colleges and universities, tuition charges fall far short of covering the full cost of the education given. By making an unrestricted "cost-of-education" grant a part of their employee scholarship or tuition-refund plans, these companies could make a material contribution toward covering the *college's* full costs as well.

The tuition supplement can be a fixed amount or a percentage of the tuition charged. Some plans provide for supplements as high as 100% of tuition, though there is usually an upper limit to the total supplemental payment given for each employee enrolled in the institution.

The plan seems to have originated with the Ford Motor Company Fund. When we at McGraw-Hill first learned of it, it appealed to us as having so many advantages, and so few disadvantages, that we adopted it as one part of our own program of financial aid.

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*The efforts of the McGraw-Hill Publishing Company to find a suitable method of aiding higher education prompted the writing of a "more or less Socratic dialog" entitled *A Business Wrestling with the Problem of Aid to Colleges and Universities*. Copies of this pamphlet, which underlines the difficulty of finding both a novel and satisfactory method of providing aid, are available on request.

HOW THE HEADS OF SOME OF THE INSTITUTIONS TO WHICH McGRAW-HILL HAS MADE GRANTS FEEL ABOUT THE TUITION SUPPLEMENT PLAN

"We are pleased not only because this addition to the never adequate supply of non-earmarked funds is a most welcome one, but also because it attests to the fact that the employees of our neighboring business firms are benefiting from the courses we offer at times convenient for them. We hope this mutually beneficial plan may continue and grow with the years."

Grayson Kirk, President
Columbia University

"I shall take this occasion to express deep sentiments of appreciation, in my own name and in the name of the members of the Board of Trustees, for the very effective manner in which your corporation is aiding higher education by the payments made under your tuition supplement plan. Certainly your action is indicative of the fact that you realize industry and higher education must join forces to preserve the basic American system of free enterprise."

Very Reverend John A. Flynn, C.M.
President, St. John's University

"The growing recognition by business and industry of the financial needs and important services rendered to the community by the colleges and universities is most encouraging, and Temple University is deeply appreciative of the fine support extended through McGraw-Hill's program of supplementary grants."

Robert L. Johnson, President
Temple University

The Plan's Advantages

The main advantages of the tuition supplement plan are:

- **It is simple and easily administered.** Payments can be made when scholarships or tuition refunds are granted, or at another time convenient to the company.
- **It relieves the company of the difficult and sometimes disagreeable task of choosing one college rather than another.** The individual employee makes the choice.
- **It directly serves the interest of the company by encouraging and aiding the institutions where its employees take courses.** In a sense, the company makes contributions in direct proportion to the value it receives in education for its employees.
- **It directly serves the interest of the colleges and universities receiving the grants by getting money to them in the form most appreciated**—unrestricted funds to be used at the discretion of their administrators.

Largely because tuition supplements are unrestricted as to use, this plan enjoys the unqualified approval and gratitude of the schools receiving such aid. This is not true of some of the other plans for granting aid to colleges and universities.

Tuition supplements, of course, can't be regarded as large efforts relative to the need of higher education and the responsibilities of business. But they are a very practical and useful first step, involving almost no problems. If you are not familiar with the idea of supplemental grants, why not discuss it with some of your friends in the field of higher education?

The Price Of Novelty

Our experience with tuition supplements indicates that this is an excellent plan, and we are glad to recommend it to other companies looking for an effective method of providing financial aid to higher education.

At any rate, we hope that business firms will not postpone granting financial aid until they find some novel way of doing it. If they do, it will be another case of too little and too late.

This message is one of a series prepared by the McGraw-Hill Department of Economics to help increase public knowledge and understanding of important nation-wide developments. Permission is freely extended to newspapers, groups or individuals to quote or reprint all or parts of the text.

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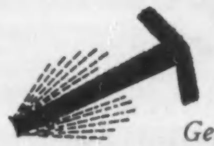

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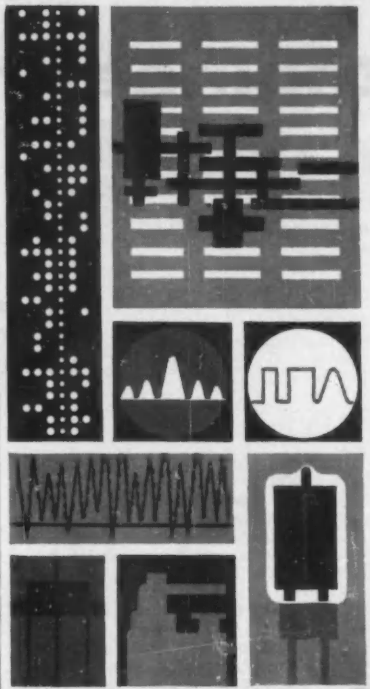

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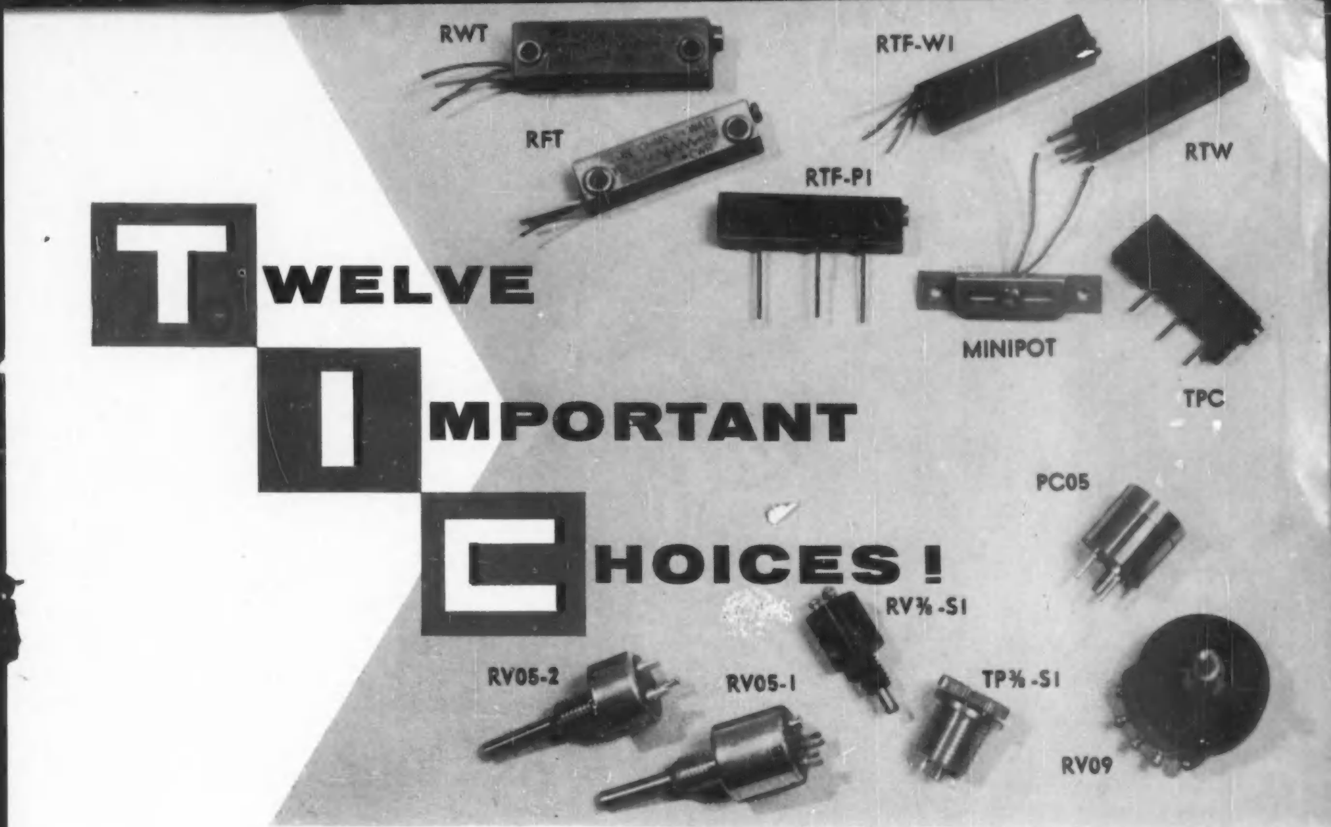

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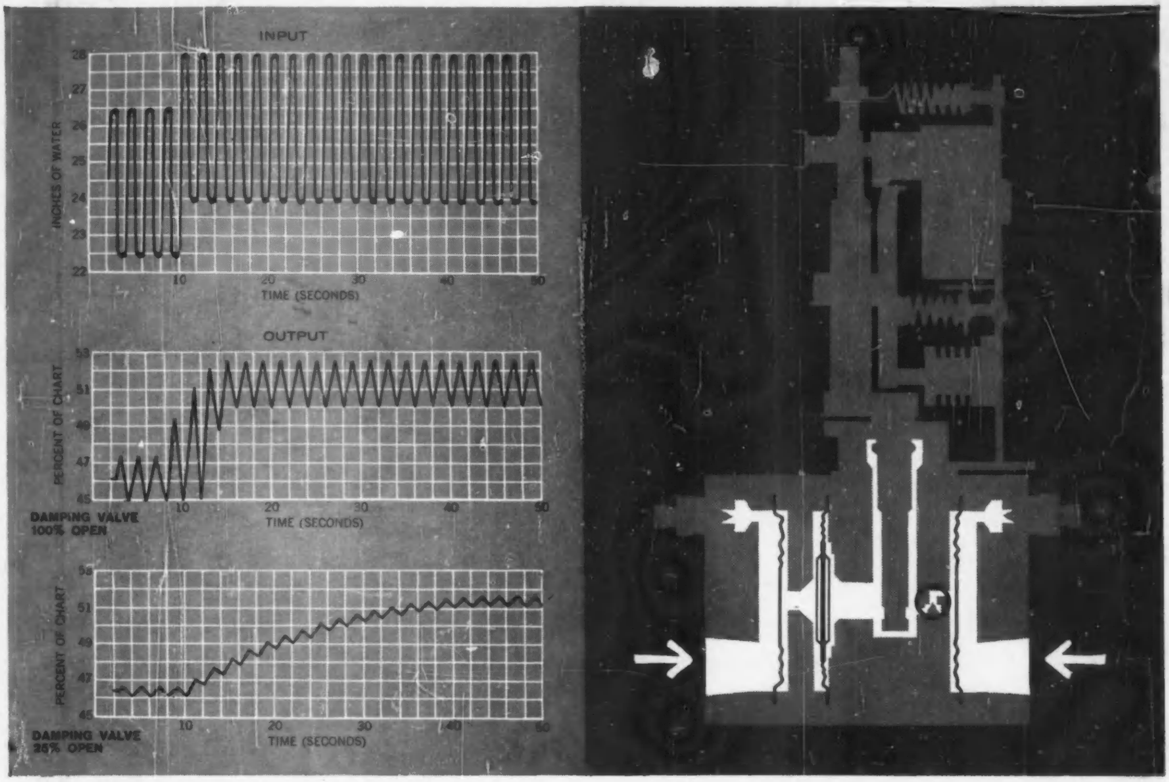

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